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USSR Report

SPACE

No. 12

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SPACE ENGINEERING

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MANNED MISSION HIGHLIGHTS

FEATURE ARTICLE ON 'SALYUT-6' DESIGN AND SUBSYSTEMS

Moscow NAUKA I ZHIZN' in Russian No 4, Apr 81 pp 44-53, 125

/Article by Yu. Semenov, doctor of technical sciences, and L. Gorshkov, candidate of technical sciences: "'Salyut-6' Orbital Station: Home, Laboratory, Vehicle"]

/Text/ It is now 3 and 1/2 years that a unique structure created by the hands of Soviet engineers and workers -- the "Salyut-6" station -- has been operating in orbit. Ships carrying both short- and long-term expeditions have docked with this scientific laboratory in space. Representatives of different countries in the socialist brotherhood have lived and worked on it, carrying out intensive scientific investigations. A list of the experiments performed on the "Salyut-6" station would fill several dozen pages, with their thematic range extending from astrophysics to medicine, from geology to the production of materials with special, "unearthly" properties. A huge amount of work has been done to study the Earth's natural resources, and this group of investigations alone has yielded an economic effect amounting to several tens of millions of rubles.

The study of the behavior of man under the conditions encountered during protracted spaceflight occupies a special place in the flight programs of orbital stations, and particularly so as far as the "Salyut-6" is concerned.

This work is of fundamental importance for selecting man's future strategy for penetrating outer space. Even today the on the agenda there is the question of building such fantastic structures as radiotelescopes that are many kilometers long and are capable of looking "beyond the horizon of the Universe" (see NAUKA I ZHIZN', No 5, 1978). Engineers from different countries are pondering plans for systems for controlling the Earth's climate or for power stations in orbit that would capture the Sun's free energy and transfer it to Earth by, for example, a narrow radio beam. What is man's role in the creation of these structures? Who is he: builder, investigator and inhabitant of our outposts in space, or an operator who stays on Earth and controls automatic machines functioning in distant orbits by means of radio?

Today we cannot yet give the final answers to these questions, but the extended expeditions on the "Salyut-6" orbital station and the development of different ways of compensating for the effect of weightlessness on the human body are important steps in the search for the answers.

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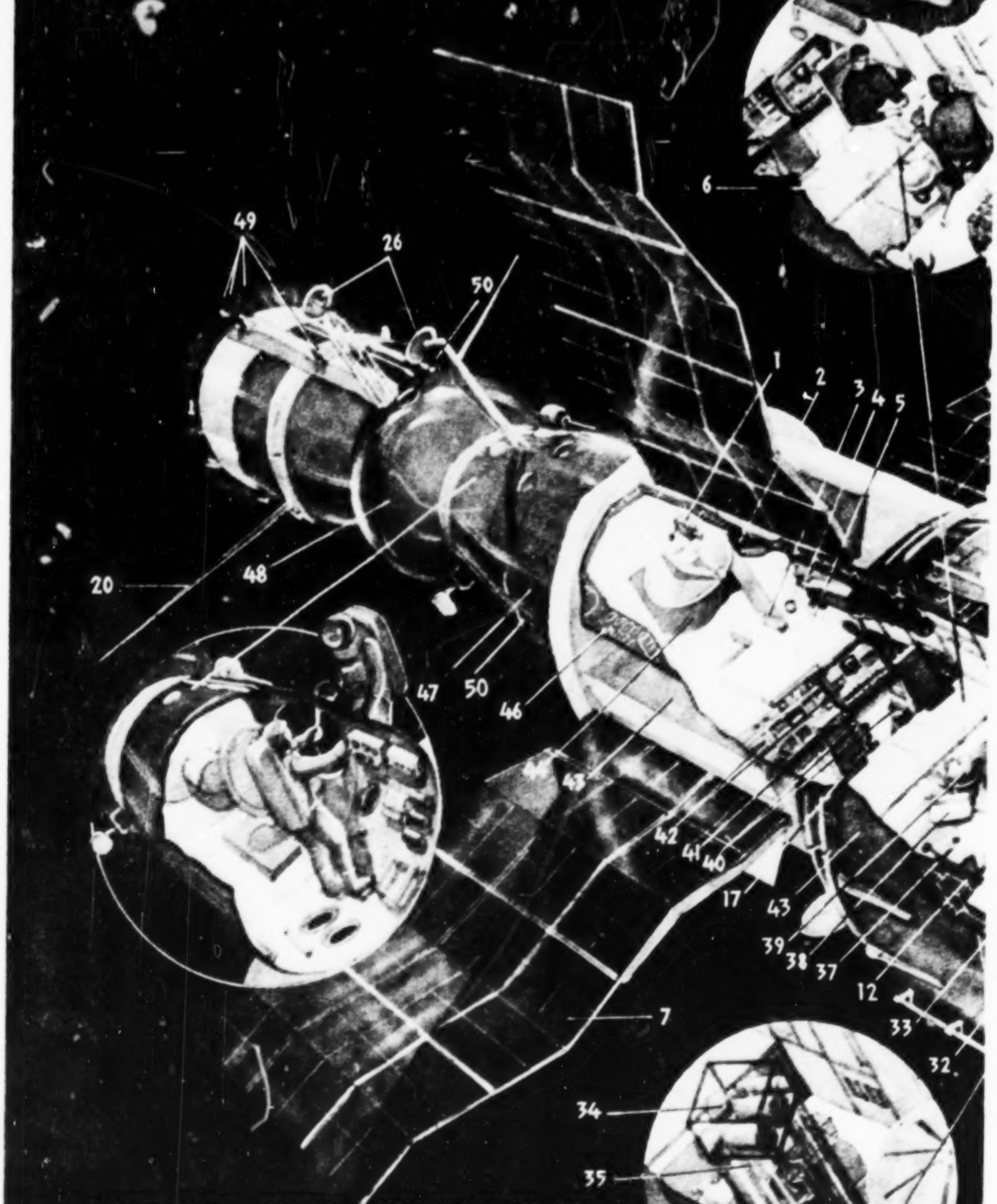
СТАНЦИЯ «САЛЮТ-6»

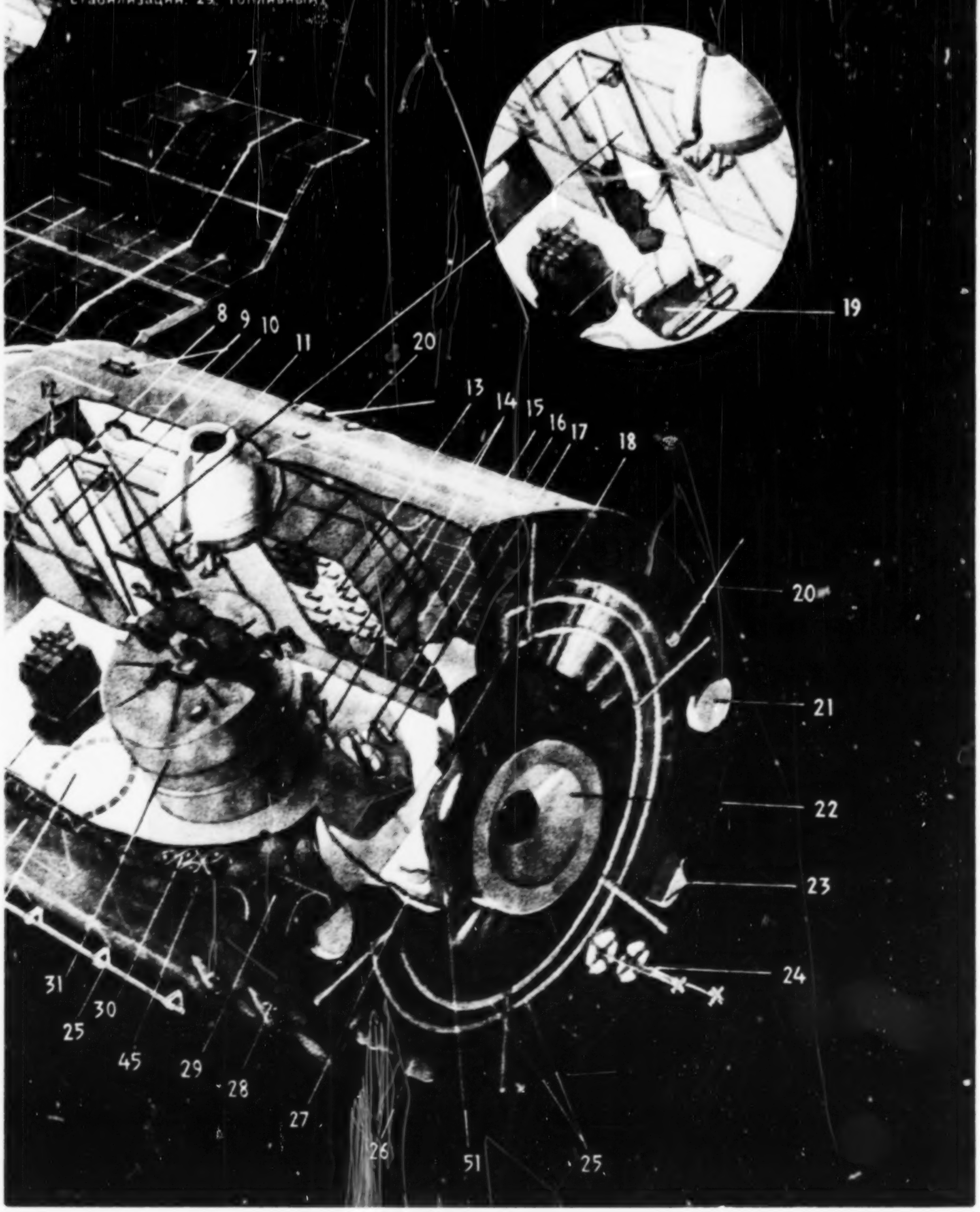
(см. статью на стр. 44).



1. Репортажная телекамера. 2. Привод солнечной батарей. 3. Огнетушитель. 4. Велоэргометр. 5. Контейнер для бортовой документации. 6. Стол для приема пищи. 7. Панель солнечной батареи. 8. Пульт управления системой регенерации воды. 9. Спальное место. 10. Внутренний поручень. 11. Шлюзовая камера для удаления отходов. 12. Приборная зона между внутренней обшивкой и корпусом станции. 13. Контейнеры с пищевыми рационами. 14. Пульты научной аппаратуры. 15. Контейнеры с питьевой водой. 16. Визир телескопа. 17. Ручка управления системы ориентации. 18. Средства

[key on second page following]

личной гигиены. 19. Тренажер «Бегущая дорожка». 20. Антенна. 21. Корректирующий двигатель с крышкой (перед включением двигателя крышка автоматически отводится). 22. Стыковочный агрегат. 23. Датчики ориентации солнечных батарей. 24. Мишени для визуальной стыковки. 25. Наружные поручни. 26. Антенна системы сближения. 27. Туалет. 28. Двигатели ориентации и стабилизации. 29. Топливный бак. 30. Сборники отходов. 31. Отсек научной аппаратуры. 32. Датчики микрометеоров. 33. Фотоаппарат МКФ. 34. Баки душевой установки. 35. Душевая установка. 36. Поддон душевой установки. 37. Прибор звездной ориентации. 38. Поворотный стул со средствами фиксации. 39. Бачок с питьевой водой. 40. Оптические приборы ориентации. 41. Кресло космонавта. 42. Центральный пост управления. 43. Рабочий отсек. 44. Люк в переходной отсек. 45. Агрегатный отсек. 46. Регенераторы атмосферы. 47. Переходной отсек. 48. Транспортный корабль «Союз». 49. Двигатели причаливания и ориентации. 50. Иллюминатор. 51. Промежуточная камера.



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The "Salyut-6" station.

Key:

1. Reporting television camera
2. Solar battery drive
3. Fire extinguisher
4. Veloergometer
5. Container for on-board documents
6. Table for eating
7. Solar battery panel
8. Water regeneration system control panel
9. Sleeping area
10. Inside handrails
11. Airlock for waste disposal
12. Instrument area between inner skin and station's hull
13. Food ration containers
14. Scientific equipment panels
15. Drinking water containers
16. Telescope viewfinder
17. Attitude system control handle
18. Personal hygiene facilities
19. "Running track" trainer
20. Antenna
21. Correcting engine with cover (before the engine is turned on, the cover is removed automatically)
22. Docking assembly
23. Solar batter orientation sensors
24. Visual docking targets
25. Outside handrails
26. Rendezvous system antenna
27. Toilet
28. Attitude and stabilization engines
29. Fuel tank
30. Waste storage tanks
31. Scientific equipment compartment
32. Micrometeor sensors
33. MKF photographic equipment
34. Shower unit tanks
35. Shower
36. Shower drip pan
37. Stellar orientation instrument
38. Swivel chair with locking devices
39. Small drinking water tank
40. Optical orientation instruments
41. Cosmonaut chair
42. Central control panel
43. Working compartment
44. Hatch to transfer compartment
45. Service module
46. Air regenerators
47. Transfer compartment
48. "Soyuz" transport ship
49. Mooring and attitude engines
50. Window
51. Intermediate chamber

Regular Routes

The main new quality of the "Salyut-6" station that has enabled it to remain in orbit for so long and to handle such a large number of expeditions is the possibility of replenishing materials that are consumed on board. The station has become the basis of an entire system of regular flights into space and the extended functioning in orbit of a scientific laboratory with replaceable crews.

One of the important elements of this system is the "Progress" cargo and refuelling ship. Its rendezvousing and docking with the station are carried out automatically, an operation that was first performed in orbit as long ago as 1967, during the flights of the "Kosmos-186" and "Kosmos-188" satellites. There are still no analogs to these automatic docking systems anywhere: as is known, docking was carried out by the crew alone on the "Gemini" and "Apollo" ships.

The creation of the transport system made it possible to formulate a new approach to the structure of the entire spaceflight program. There appeared, in particular, the possibility of periodically delivering equipment into orbit and accumulating experience in performing preventive maintenance and repair work in orbit.

The possibilities for scientific research have been enlarged, because during a flight it is possible to change and expand the program of experiments. The "Progress" cargo ships have delivered various scientific equipment to the "Salyut-6," ranging from containers with biological objects and "Kristall" technological units to a 10-meter KRT radiotelescope antenna (see NAUKA I ZHIZN', No 11, 1979).

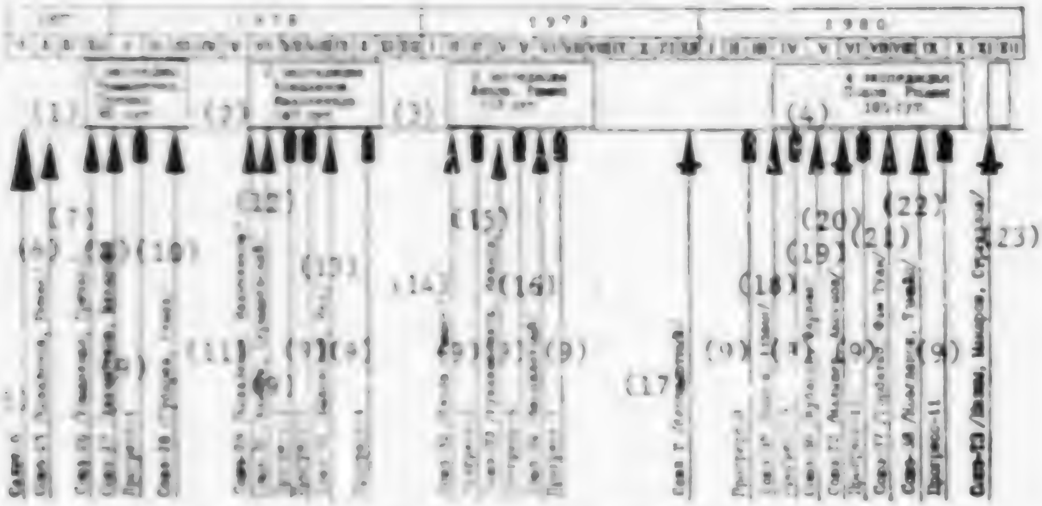
A Multiroom House in Space

The "Salyut-6" orbital station is an elongated, spindle-shaped body, the dimensions of which are determined by the conditions under which it is injected into orbit by the launch vehicle. The fact of the matter is that both the load on the rocket and the atmosphere's resistance while the complex is ascending depend on the station's diameter and length, so that increasing these two dimensions requires, in the final account, an increase in the rocket's launch weight. On the other hand, decreasing the diameter and length causes substantial complications in placing the equipment and creating comfortable working and resting conditions for the crew. Taking both the rocket's characteristics and the requirements for the station into consideration, a compromise was finally found. The present shape of the "Salyut" orbital stations is a reflection of this compromise.

In order to begin planning the station, it was first necessary to determine the number of compartments and separate chambers in it. In order to do this, in turn, it was necessary to decide how to place the basic equipment: in the same chamber in which the crew works, or separately. On a "Soyuz" ship, for example, the basic equipment is placed in a special instrument bay. The operating conditions for this equipment are close to ideal: a constant temperature and minimum humidity are maintained in the instrument bay and in its atmosphere there is no oxygen, which is the origin of all the unpleasant oxidation processes. But the cost of these ideal (for the equipment!) conditions is quite high: the crew is deprived of access to the instrument bay and does not have the capability of performing any kind of repair work that might be necessary.

For stations operating in orbit for several years and containing a large amount of the most variegated equipment, such an arrangment is hardly feasible. Therefore, the following decision was made during the planning of the "Salyut" station: all the basic systems and equipment will be placed in the same compartment where the crew lives and works, so that the cosmonauts will have access to the station's basic equipment. The only exceptions will be those pieces of equipment that, because of their functions, must be placed outside or, so to say, "off board." This means, primarily, the power plant and part of the scientific equipment, such as the telescope operating in the submillimeter band.

As a result, it was found that the station must have three basic compartments: for the crew and equipment (called the working compartment), for the power plant (the service module) and for the so-called external scientific equipment. Structurally these three compartments must be arranged in such a fashion that manned and cargo ships can dock with the working section. Since the crew must unload unmanned cargo ships, there should be a capability for docking two ships -- manned and cargo -- at the same time. Therefore, there must be at least two "moorings" or docking assemblies.



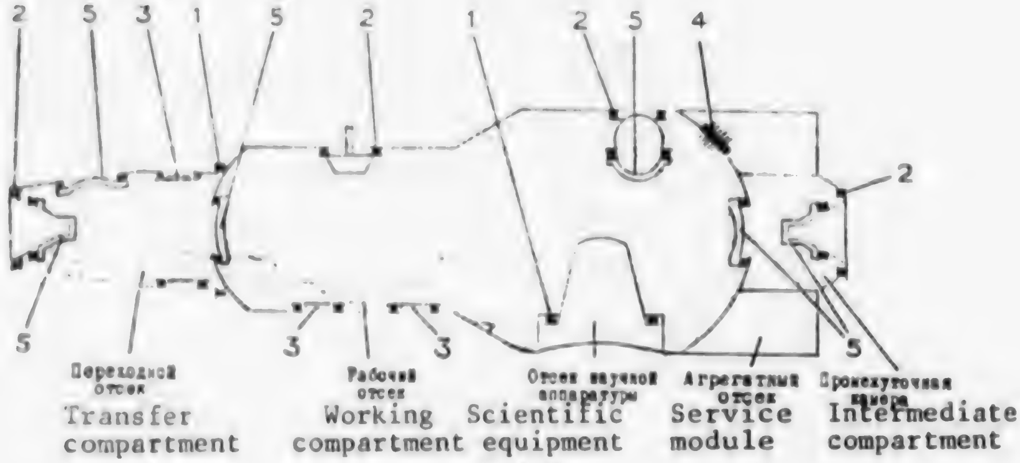
Flights to the "Salyut-6" station from September 1977 to December 1980. During this period, 4 long-term expeditions worked on the station and there were 10 expeditions of visitors, including 6 international ones.

Key:

1. Expedition 1: Romanenko, Grechko; 96 days
2. Expedition 2: Kovalenok, Ivanchenkov; 140 days
3. Expedition 3: Lyakhov, Ryumin; 173 days
4. Expedition 4. Popov, Ryumin; 185 days
5. Salyut-6
6. Soyuz-25 (Kovalenok, Ryumin)
7. Soyuz-26 (Romanenko, Grechko)
8. Soyuz-27 (Dzhanibekov, Makarov)
9. Progress-..
11. Soyuz-29 (Kovalenok, Ivanchenkov)
12. Soyuz-30 (Klimuk, Germashevskiy
13. Soyuz-31 (Bykovskiy, Jaehn)
14. Soyuz-32 (Lyakhov, Ryumin)
15. Soyuz-33 (Rukavishnikov, Ivanov)
16. Soyuz-34 (unmanned)
17. Soyuz-T (unmanned)
18. Soyuz-35 (Popov, Ryumin)
19. Soyuz-36 (Kubasov, Farkas)
20. Soyuz-T2 (Malyshev, Aksenov)
21. Soyuz-37 (Gorbatko, Pham Tuan)
22. Soyuz-38 (Kovalenok, Tamayo)
23. Soyuz-T3 (Kizim, Makarov, Strekalov)

Each docking assembly must be attached not directly to the working compartment, but to an intermediate chamber that functions as a "lobby." This provides a safety factor, since it separates the station's inhabitants from that section of the hull that the transport ship approaches during docking.

Thus, we have five sections. First of all, there are the three sealed compartments: the working compartment with its two "lobbies," one of which is called the transfer compartment, while the second is the intermediate compartment. In addition, there must also be the two obligatorily unsealed compartments: the scientific equipment and service modules. Considering the fact that during manned flight there is at least one transport ship at the station, the crew always has a five-room apartment at its disposal: besides the three sealed compartments in the station itself, there are two habitable compartments in the ship -- the crew compartment and the descent vehicle. The largest room in this apartment is the station's working compartment, which has an inhabitable space of about 40 cubic meters. For a comparison, we will mention that the volumes of the other four inhabitable areas in the "Soyuz"-"Salyut" complex are from 5 to 8 cubic meters. It is not difficult



Main sealed joints in the station's hull (total number of sealed joints -- about 400).

Key:

1. Joints between station compartments
2. Sealed joints with assemblies (airlock, solar battery drive dock- ing assembly)
3. Windows
4. Electric and hydraulic pressurization leads
5. Openable hatches

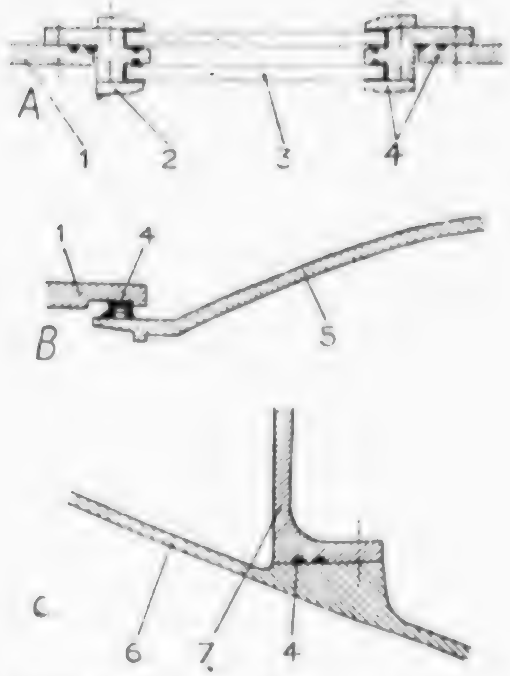
to calculate that as far as volume is concerned, the main working compartment can be compared to a room with a floor area of about 16 square meters.

A Sealed Sieve

It is easy to make the station's compartments as separate structural units, but in connection with this, of course, they must be joined together in such a fashion as to preserve the station's airtightness. From the viewpoint of airtightness, the best way to connect the compartments would have been with a welded seam. However, such a solution entails great technological difficulties in manufacturing and assembling the station. Adjacent compartments are joined to each other by a so-called sealed joint that is formed by two rings, between which there is a rubber sealing collar that also insures airtightness.

The compartments' sealed joints are not the only releasable connections on the station: some of its assemblies and units are also mounted on the hull with the help of rubber seals. As examples we can name the airlocks, the airtight solar battery drives, the docking assemblies, the windows and a number of other assemblies or parts, some of which are "in the house," while others are on the hull. The airtightness of the entire station depends on the airtightness of the connection with the hull of each such unit or assembly. The importance of the hermetic sealing question becomes understandable if we keep in mind the fact that the "Salyut-6" station has two airlocks, two docking assemblies, three solar battery drives and 23 windows.

However, this is still not everything. Part of the station equipment -- whole units of it -- is located outside the hull, part inside it. Between these outside and inside units there must be couplings (electric, hydraulic, or both at the same time). Consequently, it is necessary to have sealed electrical and hydraulic leads



Examples of sealed joints on the "Salyut-6" station.
Key:
- A. Window unit
- B. Hatch for space walk
- C. Sealed joint between station's working and transfer compartments
- 1. Station hull
- 2. Window framing ring
- 3. Glass
- 4. Rubber pressure seals
- 5. Hatch cover
- 6. Bottom of working compartment with ring
- 7. Shell of transfer compartment with ring

through the hull. There are several hundred such leads on the "Salyut-6" station; that is, the station's hull resembles a sieve with carefully made openings. Maintaining the hull's airtightness during a multiyear flight through the vacuum of space is a rather complicated engineering problem.

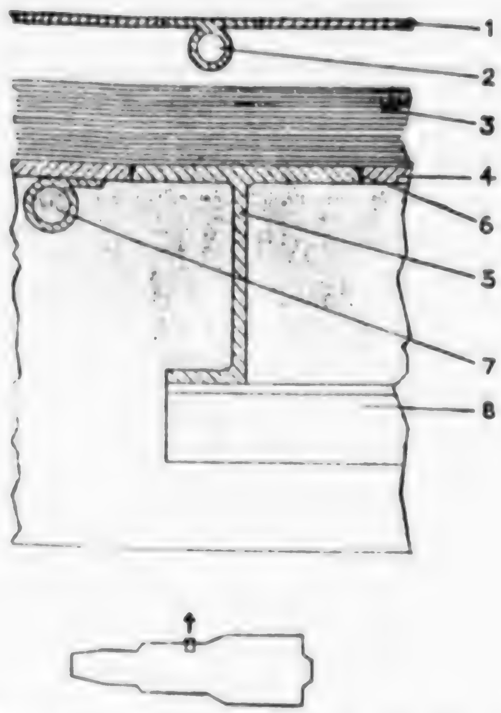
In order to solve it, in addition to careful production and working of the pressure seals themselves, it is very important to insure the stability of the hull's temperature regime. Under these conditions, in particular, rubber seals preserve their elasticity and strength better, and these qualities are of primary importance for a sealing material. In order to stabilize the hull's temperature, pipes are welded to the inside of it and through them flows a liquid -- the heat-transfer agent of the temperature regulation system.

We Enter the "Salyut-6" Station

Let us enter this "space house" through the transfer compartment hatch, which is the way the crew enters it after a manned transport ship docks with the station. Having opened the hatch cover in the docking assembly, we enter the transfer compartment, a small area with a volume of about 8 cubic meters. In it there are two pressure suits and the airlock control panels -- the transfer compartment is not only a "lobby," but also the airlock that enables the cosmonauts to exit into open space.

Through the next hatch we now enter the station's main room: the working compartment. Before us is a spacious room, the walls and ceiling of which are removable panels covered with a soft, bright-colored cloth. Here, almost immediately in front of the access hatch, is the station's central control post.

Let us take the crew's place at the central post and try to familiarize ourselves with the control panels. Directly in front of us is the central panel: in its upper left corner we see a "globe," which is an instrument that constantly indicates over what point on the Earth's surface the ship is located. Beside it there is a panel with light signals that report on the status of the station's systems: green lights inform the crew about the status of the station's systems; yellow ones warn about important orders arriving from Earth or given by the crew itself during the process of controlling the station. Red lights are emergency signal indicators.



Example of cross-section of the station's hull. The station's pressure shell is clad in a "fur coat" consisting of vacuum-shielding insulation, on top of which the temperature system's radiators are mounted. Thermostatic control pipes lead from inside to the hull. In order to increase the hull's load-bearing capacity (strength), the main frames that are used to attach the internal elements of the station have been welded to it.

Key:

1. Outside radiator
2. Cooling network pipe
3. Multilayer vacuum-shielding insulation
4. Station's pressure hull
5. Frame ring welded to hull
6. Welding points
7. Hull thermostatic control pipe
8. Framework for attaching internal station elements.

The main part of the on-board system control commands are sent from two so-called command signal systems that are located to the left and right of the central post.

On the left is the crew life support system control panel and on the right there is the refueling control panel. On the instrument panel of this unit there is a propulsion system graphic control panel that reflects the completion of all the refueling processes: triggering of valves, gas evacuation, flow of fuel and oxidizer.

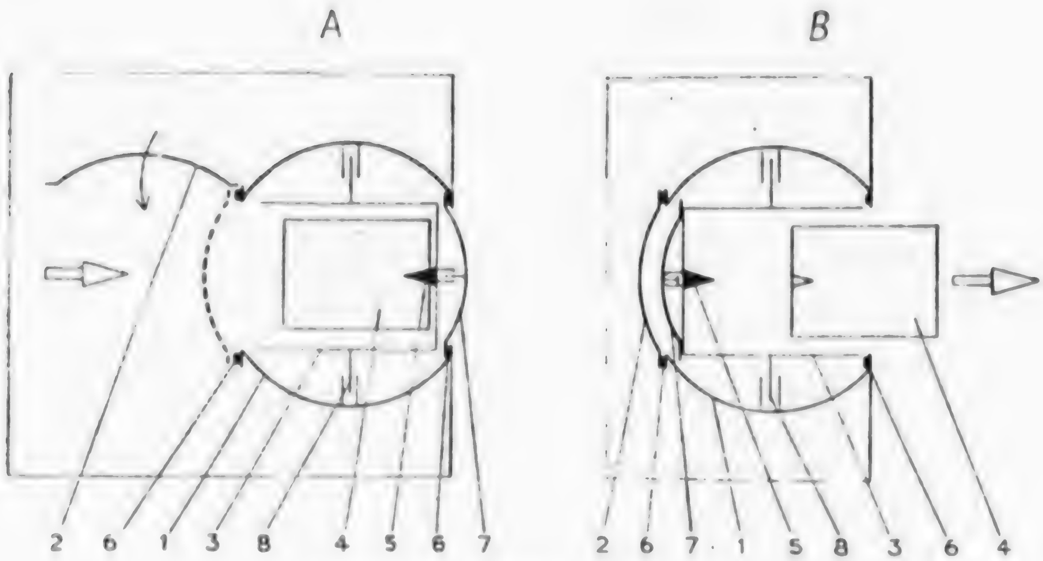
Immediately behind the central post there is a table for working and eating, and near the table there is a spherical tank that contains water. Farther beyond the table a large cone is visible; this is the scientific equipment compartment. On the "ceiling" to the right of it there is a shower unit in stowed position. Farther on the ceiling there are two airlocks for disposing of garbage.

As soon as extended manned flights into space began, there arose the problem of disposing of the wastes generated by vital activity. Airlocks were developed for this purpose, and garbage is disposed of through them in small containers that eventually burn up in the Earth's atmosphere.

The presence of two shells -- a movable and an immovable one -- in the airlock makes it possible to place a container in in it and dispose of it relatively quickly.

"Splav" and "Isparitel'" units are located in one of the airlocks, which enables them to be placed in their working positions in space quite rapidly. The "Splav" and "Isparitel'" units make it possible to perform new technological processes and produce materials with unique. qualities.

Behind the cone that is the scientific equipment compartment, we can see a soft door with a zipper fastener, beyond which is the toilet. Beyond it is the hatch into the intermediate chamber, which is sort of inside the service module and leads directly to the second docking assembly's hatch.



Container disposal airlock.

Key:

A. Installation of container to be disposed of: the movable chamber is turned with its opening into the station and the pressure cover on the movable chamber is clamped to the pressure seal.

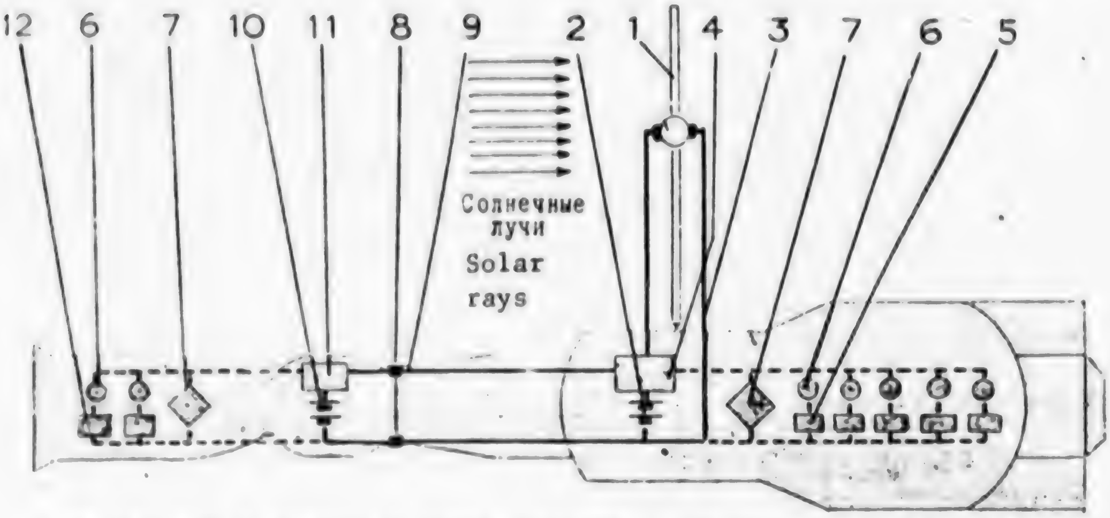
B. Disposal of container: the movable chamber is turned with its opening outward.

1. Immovable chamber
2. Immovable chamber hatch
3. Movable chamber
4. Container
5. Ejection mechanism
6. Pressure seal
7. Pressure cover on movable chamber
8. Axis of rotation

Thus, we have now toured the entire station and gone through all its sealed compartments, from one docking assembly to the other. Now let us return to the working compartment and take a look at the panels forming the walls, floor and ceiling. After removing one of the panels with a special tool kept in the "workshop," we see a frame-type construction inside which there are rows of instruments. Between the panels there is a cable network laid through accurate holes. The wires from all the instruments run into these cable holes like brooks into a river. If we disconnect the cables from the instruments -- they are joined together by detachable plug-and-socket connections -- and unscrew the bolts with which the instruments are fastened to the frame, we can also remove the instruments. Behind them we see the matte surface of the station's aluminum hull, with the thermal conditioning system pipes that are welded to it.

The Sun Gives Energy

This station -- a complex spacecraft and a complex machine -- is equipped with a whole series of units that perform the most variegated functions in the control, thermal conditioning, life support, orientation, communication and other systems. Energy, and above all electricity, is needed to run these systems. The main source of electricity on the "Salyut" station is solar batteries. These are flat panels filled with silicon photocells that convert the energy in solar radiation to electricity. There are three solar batteries on the station, each of which has an area of 20 square meters and can be turned by a special electric drive on the basis of



The station's electric power systems. The source of electricity is a solar battery that charges chemical storage batteries in the station and the ship.

Key:

1. Solr: battery
2. Storage battery
3. Circuit for charging station's storage batteries
4. Power source monitoring unit
5. Station equipment
6. Current protection
7. Transformer (alternating current source)
8. Electrical connections
9. Circuit for charging ship's storage batteries
10. Ship's storage battery
11. Ship's power source monitoring unit
12. Ship equipment

signals from the Sun position sensors. The automatic unit turns the panels in such a fashion that they receive the maximum illumination from the Sun's rays.

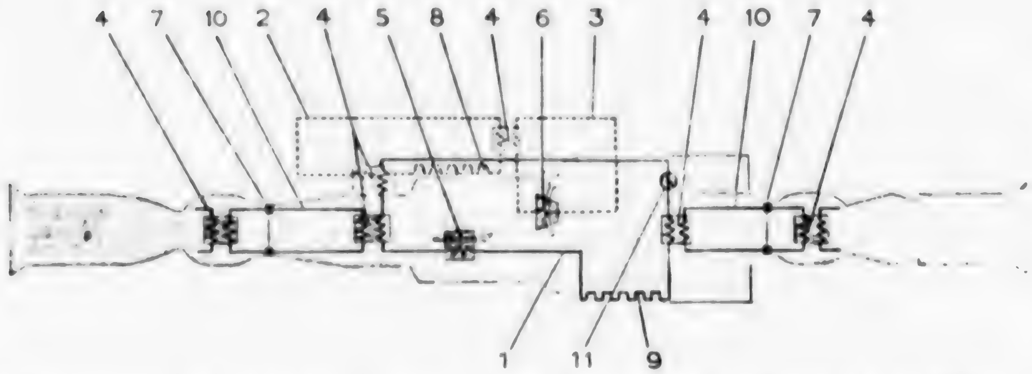
The electricity produced is used to recharge on-board storage batteries that power all the station's equipment. In the electric power system there are transformers to supply the different station and scientific equipment with alternating current. The power system and the cable network are protected against short circuits: if the current in any instrument or unit exceeds the rated level, the instrument or unit is immediately disconnected.

After a transport ship docks at the station, the electric power systems of both spacecraft are connected through an electrical outlet in the docking assembly. The ship's storage batteries are recharged and it functions at the station's "expense" until it undocks before departing.

Climate on Order

A temperature of about 20°C is maintained inside the crew quarters, although the crew can change it, within certain limits, if they wish to. The temperature regulation system also maintains given temperature regimes inside the instrument zone, on the hull, and in different structural elements on the outside of the station.

The most important element of the thermal regulation system is the "fur coat" of so-called vacuum-shielding insulation. This is essentially a multilayer thermos



Temperature regulation system. The branched network of hydraulic mains and the heat-exchange and other units maintain a given air temperature in the crew quarters, modules, station hull and transport ships. Excess heat is radiated into space by the external temperature regulation circuit's radiator.

Key:

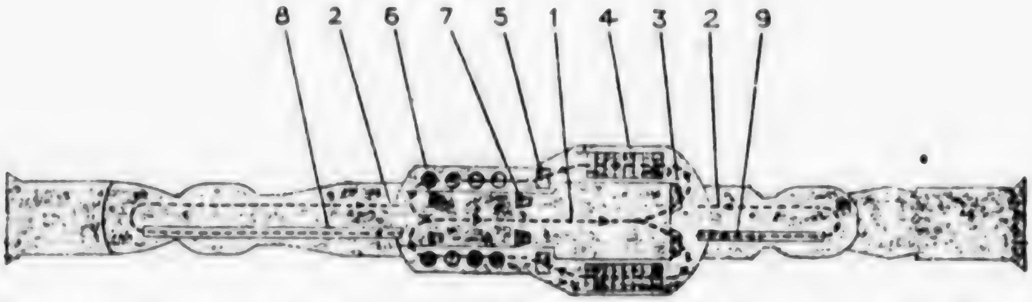
1. Station heating circuit
2. Station cooling circuit (external)
3. Station cooling circuit (internal)
4. Liquid-liquid heat exchanger
5. Gas-liquid heat exchanger
6. Cooling and drying unit
7. Docking assembly's hydraulic connector
8. External radiator
9. Hull thermal conditioning pipes
10. Ship heating circuit (intermediate)
11. Electric heater

made from a metallized film, the purpose of which is to preserve the heat inside the station.

This heat is generated by the people themselves and by any equipment that is operating. As a rule, during a flight with a crew the amount of heat generated is such that with a good "fur coat" and good external heat insulation, it can become too hot inside the station. Therefore, the temperature regulation system's typical problem is to eliminate the excess heat. It is collected by the so-called heating circuit, the purpose of which is to heat the station's structural elements. The heat is accumulated in the heating circuit by means of a gas-liquid heat exchanger: a blower drives the warm air filling the compartment through a coil containing a liquid heat-transfer agent, which enters the pipes of the heat exchangers located inside the compartment.

The excess heat is discharged "to the outside" through a radiator and the part of the station's outer skin to which the pipes of the external cooling circuit are welded. Heat is transmitted from the internal heating circuit to the external cooling circuit through a heat exchanger where the coils of both circuits are arranged so as to insure maximum transmission of heat through the walls of the pipes. In the system there is a regulating stopcock that changes the amount of liquid heat-transfer agent passing through the heat exchanger and, consequently, the degree of cooling of the liquid and the hull heating circuit.

If there is no crew in the station and the equipment is functioning in the standby mode, the air temperature inside the compartments can be raised by an electric heater.



Ventilation diagram. Forced air circulation is created in the station by means of several dozen blowers. The air cools the equipment as it passes through the instrument area; it is enriched with oxygen in the regenerators, cooled in the gas-liquid heat exchangers and continuously cleaned in the filters.

Key:

1. Station ventilation circuit
2. Ship ventilation circuit
3. Filters for dust and harmful impurities
4. Basic station equipment area (the air is heated and equipment cooled)
5. Temperature regulation system's liquid-liquid heat exchanger (the air is cooled)
6. Atmospheric gas regenerators and carbon dioxide absorbers (the air is enriched with oxygen)
7. Cooling and drying units (the air is cooled and moisture precipitates on the units' cold surfaces)
8. Cargo ship ventilation duct
9. Manned ship ventilation duct

The temperature regulation system has yet another function: removing moisture from the atmosphere in the crew quarters. In order to do this there is an internal cooling circuit that includes so-called cooling and drying units. Moisture settles on the cooled (about $5^{\circ}C$) surfaces of these units and is pumped into special storage tanks, after which it passes into the system for regenerating water from condensate.

After docking, the station's temperature control system is connected to that of a transport ship through hydraulic connectors in the docking assembly. The station's internal heating circuit then also heats the ship, the equipment in which is idle (for all practical purposes) when it is part of a "Salyut"-"Soyuz" complex and so does not generate heat.

A Manmade Atmosphere

The gas support system maintains the parameters of the station's atmosphere within the limits to which inhabitants of the Earth are accustomed: atmospheric pressure -- 700-960 mm Hg; partial oxygen pressure -- 160-240 mm Hg; partial carbon dioxide pressure -- no more than 7-9 mm Hg.

The atmosphere regenerators are nonreusable chemical cartridges in which carbon dioxide is absorbed and oxygen generated in accordance with the following reactions:

$$4KO_2 + 2H_2O = 4KOH + 3O_2;$$
$$2KOH + CO_2 = K_2CO_3 + H_2O.$$

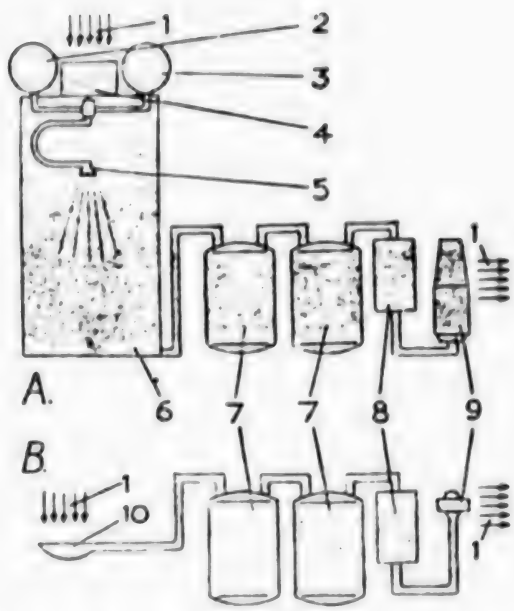


Diagram of shower unit and waste management system. In a shower unit operating in weightlessness, warm air forming the flow of water is pumped through the stall. The liquid is then removed, collected in sealed storage containers (tanks) and discharged from the station. After being cleaned, the air is returned to the crew quarters. The waste management system (toilet) functions analogously.

Key:

- A. Shower unit
- B. Waste management system
- 1. Air flow
- 2. Storage tank with hot water
- 3. Storage tank with cold water
- 4. Air heater
- 5. Moisture sprayer
- 6. Shower stall
- 7. Replaceable (disposable) tanks
- 8. Air filter
- 9. Pump
- 10. Collector

The system also contains pressure sensors that alert the crew to any unplanned drop in pressure, which is possible if the station's airtightness is compromised. Some gas losses are inevitable when the transfer compartment is unsealed for a space walk and when garbage containers are disposed of through the airlocks. These losses are compensated for by gas delivered in high-pressure tanks by cargo ships.

Under conditions of weightlessness there is no convection, which facilitates the mixing of air under terrestrial conditions. Therefore, forced air circulation is created in the station. Blowers are used to move the air from the central post in the working compartment's crew quarters to the opposite part of the station, where it enters the intake gratings of the dust and harmful impurity filters. Then the flow branches and returns to the central control post through the instrument area along the left and right sides.

When it passes through the regenerator cartridges the air is enriched in oxygen and enters the crew quarters through broad air ducts, which are purposely made broad so that there will be no fast air currents or, more simply, drafts.

In order to ventilate the compartments of transport ships, in the station there are additional air ducts that run through the hatches, while the air is pumped by blowers.

A Space Buffet

Allowing for the natural difference in tastes, the food for the cosmonauts is selected on Earth with due consideration for the wishes of each member of a crew. On the menu there are first courses (soups and cabbage soup) in tubes, different preserved meats in tins, milk products, fruits, juices, tea and small slices of bread ("enough for a single bite") in polyethylene packages. A food heater and the hot water available in the station make it possible to organize a normal hot meal.

Food in the form of dry rations is kept in two cupboards on the right and left sides of the working compartment.

The crew's water requirements are satisfied from two sources. First, the water entering the station's atmosphere because of breathing and sweating is regenerated and satisfies half the requirement. Secondly, water is delivered via the "Progress" transport ships in a system with the beautiful name "Rodnik" (Spring") whence it is pumped into the station's storage tanks.

The water regeneration method is as follows: the moisture collected in the cooling and drying units is pumped into purification units where it is filtered, sterilized and accumulated in storage tanks for consumption. There are no provisions for water regeneration from urine on board the "Salyut-6."

Shower and Toilet

The problem of building a shower under weightless conditions is not a very simple one. How does one organize the flow of water? How is it collected after being used for bathing?

Showering on board the "Salyut-6" station proceeds as follows: the cosmonaut enters a soft polyethylene stall with a waterproof zipper seal; atomizers feed a directed and organized water into the stall from above. Warm air is pumped through the stall, as a result of which the water is carried into a collector. As on Earth, the cosmonaut bathes himself, using soap and a sponge. In order that the water and the washing materials not get into the bather's mouth, nose and eyes, he has to breathe through a hose with a mouthpiece and cover his eyes.

In the waste management unit (toilet) there is also an air flow that carries away the wastes of human vital activity, as a result of which they are gathered in special containers that are then disposed of through the airlocks and burn up in the atmosphere.

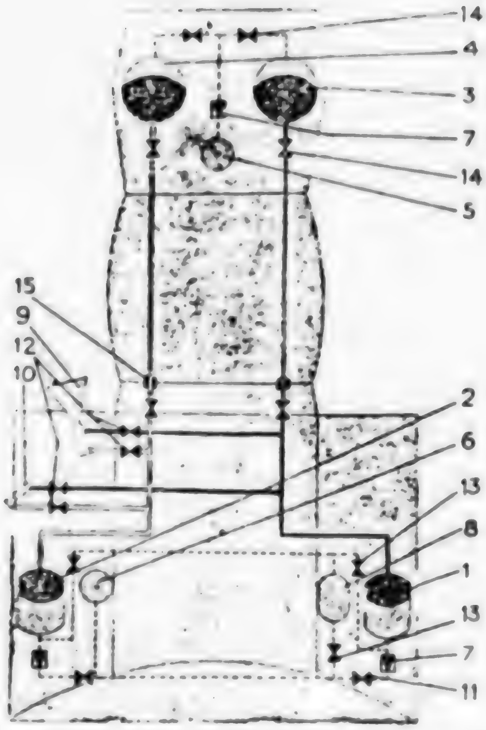
A "Stadium" on Board

An extended flight under conditions of weightlessness entails a sharp decrease in the physical loads on a man's muscles and cardiovascular system. On the "Salyut-6" station there is a complete set of facilities and equipment for making up this load deficit.

Utilizing the turning of pedals with legs, the "Veloergometer" unit makes it possible to impart a certain load to the leg muscles and the cardiovascular system. The "Running Track" is an area with a moving belt to which a man can be pressed by rubber stays, which makes it possible to subject him to loads close to those that are undergone when running on Earth. "Bicycle Races" and "Cross-Country" are carried out every day during extended flights.

Load suits fitted with rubber stays are used for effective training of the other groups of muscles: when the position of the body is changed -- when the arms and legs are flexed, for example -- the resistance in these stays is overcome and the necessary work is performed.

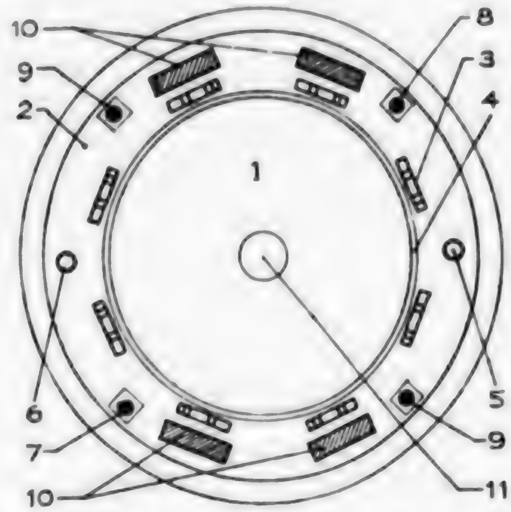
Maneuvers in Orbit



Station power plant refueling diagram.

Key:

1. Power plant fuel tank
2. Power plant oxidizer tank
3. Fuel (refueling) tank on cargo ship
4. Oxidizer (refueling) tank on cargo ship
5. Tank with gas for displacing fuel during refueling
6. Tank with gas for supplying fuel to engine
7. Reduction gear
8. Compressor for pumping gas out of tanks
9. Orbital correction (service propulsion) engine
10. Orientation engine
11. Valves of the control system for supplying fuel to the engine
12. Engine starting valves
13. Gas discharge valves
14. Refueling valves
15. Docking assembly hydraulic connectors



Station docking assembly ring through which it connects with a ship. The locks tighten the two rings of the ship and the station together. The coupling's airtightness is provided by a rubber sealing ring.

Key:

1. Guide cone
2. Docking assembly ring
3. Joint tightening lock
4. Joint sealing surface
5. Guide pin
6. Guide opening
7. Hydraulic oxidizer charging connector
8. Hydraulic fuel charging connector
9. Hydraulic coupling for temperature control system's circuit
10. Electrical coupling
11. Socket for holding pin of ship's docking assembly

During a flight the station must be oriented in space, particularly so that the scientific instruments can be aimed at the proper regions of space and the Earth's surface and so that the station's orbit can be corrected or a rendezvous with a visiting ship can be kept.

Using various sensors, the orientation and motion control system orients the station relative to the Sun, stars and the Earth's surface.

There are several orientation modes. The "infrared vertical" sensor is used for orientation in the so-called orbital system of coordinates, where the station

occupies a certain position relative to the plane of its orbit and the local horizon (it revolves around the Earth together with the station). This mode is used for orbital corrections and the conduct of scientific research involving observations of the Earth's surface, atmosphere or horizon.

When orienting the station, the cosmonauts can make use of sights in order to determine their location relative to some spatial reference point or another. On the station there is a wide-angle sight with a field of view of about 180° that is used for rapid searches for the Earth, the Sun and the Moon. There is also a sight for determining the station's position relative to the Earth and astro-orientation instruments that the cosmonauts use to orient the station relative to stars so that astrophysical research can be carried out. Gyroscopic devices that maintain a given station position for a certain amount of time (such as when the power plant is in operation) are used to stabilize the station in space after the completion of the orientation process.

There is a special orientation and motion control system operating mode that is used when a manned or cargo ship is approaching the station. In this case the station operates in close collaboration with the orientation and motion control system of the ship itself, and the entire approach process is broken down into three stages.

In the first stage the ship enters the rendezvous zone and there is a correction in the ship's -- and, when necessary, the station's -- orbit. Orbital parameter measurement data obtained from Earth are used in order to do this. The orbits are corrected so that in about a day (two days for cargo ships), in a short period of time the station and the ship have reached a distance several kilometers from each other. The automatic approach equipment is turned on at this time.

In the second rendezvous stage, the parameters of the ship's and the station's relative motion are determined and the values and directions of the correcting impulses are computed (on the ship itself). These impulses change the ship's orbit so that it approaches the station to a distance of no more than 200-300 meters. An "Igla" ("Needle") radio system, the equipment of which is located on both spacecraft, determines the parameters of the relative motion of the ship and the station. In this stage the station's orientation and control system holds the docking assembly to be used (the transfer compartment or the intermediate compartment) steady on the approaching ship.

The third rendezvous stage -- final approach -- begins after the ship has approached to within 200-300 meters of the station. The ship's main engines are no longer on and it approaches the station under the power of its mooring engines, which are arranged in such a fashion as to provide progressive motion of the ship in any direction necessary. In connection with this, the station's orientation and motion control system functions in the same manner as in the second stage.

At the end of the final appraoch, the ship moves toward the docking assembly at a speed of about 3 meters per second and the two docking assemblies come together.

In addition to the "Igla" automatic rendezvous radio equipment, on the station there is a complex of optical indices and targets that enable the crew to monitor the correctness of the automatic units' functioning and, when necessary, carry out manual mooring of a manned ship.

The Station's Engines

The ship's propulsion system is a multifunctional one that contains two groups of reaction engines. The main engines (two combustion chambers with about 300 kilograms (force) of thrust each) are needed to correct the station's orbit for the purpose of compensating for any lowering of the orbit because of braking in the atmosphere. When necessary, these engines are also used for corrections when the station is rendezvousing with a cargo ship. The low-thrust (32 combustion chambers with 14 kilograms (force) of thrust apiece) engines are used for turns and spatial orientation on command of the orientation and motion control system.

The system for suppling fuel to the engines' combustion chambers is a displacement system; that is, on command from the control system, gas from high-pressure tanks is fed into the fuel and oxidizer tanks and displaces the fuel into the combustion chambers (see NAUKA I ZHIZN', No 7, 1979).

In order that the fuel and the gas do not mix in the tanks, they are separated by a metal bellows-type membrane. When the tanks are completely charged, the membrane occupies its extreme position near the gas main, and when fuel has been consumed and the tank is filled with gas, the membrane occupies its other extreme position, near the fuel main.

After their fuel has been consumed, rocket engines are usually through functioning. For the "Salyut-6" station, however, a multiple-use propulsion system has been developed.

After the fuel has been consumed in the propulsion system, a "Progress" cargo and refueling ship docks at the station and its tanks, containing fuel and oxidizer, are connected to the refueling mains of the station's propulsion system. However, the delivered fuel cannot be transferred immediately, since it is first necessary to remove the gas from the station's tanks that was used in order to displace the fuel from them.

Therefore, the first thing that is done is to turn on a compressor that pumps the gas back into the high-pressure tank, after which the gas system is again ready to force fuel from the tanks into the combustion chambers. The tanks themselves are now ready to receive the fuel that the refueling ship has brought. After the gas is pumped out, the cargo ship's own displacement system is used to move the oxidizer and the fuel, in sequence, into the station's propulsion system's tanks.

Moorings

On the "Salyut-6" station there are two docking assemblies: one in the transfer compartment and one in the intermediate section. These are so-called passive docking assemblies, whereas the active assemblies are on the ships. A passive assembly is a receiving cone with a socket for capturing an active assembly's basic element: rods or -- in other words -- pins.

For the sake of brevity, all of this docking system is called a "pin-cone" system.

During the docking process, the active assembly's pin enters the receiving cone, slides along it, and enters the receiving cone's socket, where it is secured.

After this, the relative motions of the ship and the station are damped by a system of shock absorbers and the docking assembly rings approach each other and are coupled. There are guide pins and holes in the rings for accurate joining. Finally, the ring locks are fastened and hermetically sealed. This seal is airtight because there are two rubber sealing rings on one of the frame rings.

On the frame rings there are four electrical connections, for the power, control and electrical circuits. There are also four hydraulic connections on the rings, two of which are used to refuel the propulsion system with fuel and oxidizer (in the case of docking with a "Progress" ship), while the other two connect the ship's and station's temperature control systems.

The "Salyut" station's docking assemblies are hospitable moorings that had been visited by 13 crews and 12 "Progress" ships by the end of last year. By the way, these ships delivered cargo to the station that exceeded its original mass.

A station of the "Salyut" series is a tool for studying space and the Earth's atmosphere and surface. Since 1971 these stations have been almost constantly on duty around our planet.

Expeditions change and the stations themselves are replaced, with improvements being made from model to model. The only constant is human inquisitiveness, which with each new flight obtains new information on the Universe, our planet and the world in which we live.

11746
CSO: 1866/122

CHRONOLOGY OF 'SOYUZ-40' MISSION

[Editorial Report] The Soviet News Agency TASS reports the following information on activities connected with the flight of "Soyuz-40":

14 May

The "Soyuz-40" spacecraft was launched in the Soviet Union at 2117 hours Moscow time on 14 May 1981. The crew consists of pilot-cosmonaut Leonid Popov and cosmonaut-researcher Dumitru Prunariu of the Socialist Republic of Romania. The flight program includes docking of the "Soyut-40" with the "Salyut-6" -- "Soyuz-T4" complex and joint experiments with cosmonauts Kovalenok and Savinykh who have been in orbit since 12 March. [Moscow TASS in English 1943 GMT 14 May 81]

15 May

By 1300 hours Moscow time the "Soyuz-40" had completed 10 orbits of the earth. The first two-burn rendezvous maneuver has been carried out. After the mid-course correction the orbital parameters of the "Soyuz-40" were: apogee, 307 km; perigee, 260 km; period, 90.1 minutes; orbital inclination, 51.6 degrees. [Moscow TASS in English 0939 GMT 15 May 81] At 2250 hours Moscow time on 15 May the "Soyuz-40" docked with the "Salyut-6" -- "Soyuz T-4" complex. The scientific program, prepared jointly by Soviet and Romanian scientists, is designed to last 7 days. The program includes earth resources and environmental studies, physical-technical experiments and biomedical research. [Moscow TASS in English 2250 GMT 15 May 81]

16 May

The workday of the crew began at 1400 hours today and will last until 2400 hours. Medical tests were performed to determine initial adaptation to weightlessness. Cosmonauts Popov and Prunariu will carry out a number of astrophysical and technical experiments using equipment brought aboard the "Soyuz-40". The cosmonauts will install dielectric detectors in the station's work compartment and airlock to record heavy charged particles. In the second airlock the crew will install the "Nanovesi" unit for study of the effects of space on construction materials. Cosmonauts Kovalenok and Savinykh will assist the "Soyuz-40" crew. They will install an instrument to record dynamic disturbances caused by operation of the equipment on the station. [Moscow TASS in English 1016 GMT 16 May 81]

17 May

In today's work program a great deal of attention was devoted to medical experiments. One experiment involves determination of the effects of specific factors such as weightlessness, absence of support, and complexity of tasks on processes of information perception. The "Ballisto" and "Neptun" experiments study cardiac muscle tone and contraction and the acuity of the cosmonauts' depth erception. In the "Nanovesy" experiment the cosmonauts will determine changes in the mass of a silicon dioxide film, a material which may be used for protecting various optical elements of space apparatus. The "Astro-2" experiment records heavy charged particles in space radiation. This experiment is designed to take into consideration the orbital position of the space complex in order to determine the effect of the earth's magnetic field on the particle streams. Kovalenok and Savinykh today installed the "Pion" unit to study convection currects in fluids in weightlessness. During the day they also recorded the activity of the crew on motion picture film. [Moscow TASS in English 1155 GMT 17 May 81]

18 May

Popov and Prunariu are conducting the "Mini-Doza" experiment to evaluate the component from earth's radiation belts in total space radiation in near-earth space. The experiment uses Romanian and Hungarian instruments. In the program of medical studies, Popov and Prunariu performed experiments to determine the speed and accuracy of an operator's work in spaceflight conditions. A TV press conference with correspondents at the Mission Control Center is scheduled for this evening. [Moscow TASS in English 1037 GMT 18 May 81]

19 May

In their fourth day aboard the orbital complex the crew will perform the "Kapillyar" experiment using the "Kristall" apparatus. The experiment, designed jointly by Soviet and Romanian scientists, studies growth of monocrystals of a given profile in conditions of microgravity using the effect of capillary attraction. During the day, cosmonauts Popov and Prunariu will carry out planned operations with the "Nanovesy" and "Astro-2" experiments and record their activities on film. In the medical program the cosmonauts made another series of tests of the cardiovascular system and acuity of depth perception. Cosmonauts Kovalenok and Savinykh are performing technical experiments. In one of these they measure the dynamic characteristics of the orbital complex and its structural loading; in another they are working on methods of increasing the accuracy of spacecraft orientation. The cosmonauts are also continuing biological experiments, including studies of plant mutation in spaceflight conditions. [Moscow TASS in English 1113 GMT 19 May 81]

20 May

Cosmonauts Popov and Prunariu are working on the "Rabotosposobnost'", "Operator" and "Informatsiya" experiments. Using a specially prepared list of questions they will assess their subjective sensations during the period of adaptation to spaceflight conditions. The experiment to study effects of space on structural materials

has been completed. The cosmonauts have dismantled the "Nanovesy" apparatus in the airlock and installed in its place the "Splav" electric furnace in order to perform a "Kapillyar" experiment on production of monocrystals of a required type. Cosmonauts Kovalenok and Savinykh are continuing the biological experiments. They will also take air samples from the station's living quarters to study conditions in the closed ecological system. An orbital correction maneuver will be performed today using the propulsion unit of the "Soyuz-40" craft. [Moscow TASS in English 1056 GMT 20 May 81]

21 May

Cosmonauts Popov and Prunariu are completing their work aboard the orbital complex. This morning they took samples of air and microflora in the station for subse uent laboratory analysis and carried out final operations with other experiments. A study of the circulatory system was carried out with simulation of the effect of hydrostatic pressure. The cosmonauts have begun loading experimental materials into the "Soyuz-40" descent vehicle and are checking its systems. [Moscow TASS in English 0918 GMT 22 May 81]

22 May

At 1758 hours Moscow time on 22 May 1981 the "Soyuz-40" cosmonauts returned to earth. Cosmonauts Popov and Prunariu landed in the "Soyuz-40" descent craft 225 kilometers southeast of Dzhezkazgan. During the seven-day flight the international crew fully completed the planned program of research and experiments. [Moscow TASS in Russian 23 May 81]

CSO: 1866/135-P

TASS REPORTS LANDING OF 'SOYUZ T-4' COSMONAUTS

Moscow PRAVDA in Russian 27 May 81 p 1

[Summary] At 1638 hours Moscow time on 26 May 1981 cosmonauts Vladimir Kovalenok and Viktor Savinykh returned to earth after successfully completing the planned flight program aboard the "Salyut-6" complex. The "Soyuz T-4" descent craft landed 125 kilometers east of the city of Dzhezkazgan. A medical examination on the spot showed that the cosmonauts were in good condition.

During their 75-day flight the cosmonauts carried out a program of geophysical research, earth observation and photography, materials experiments and biomedical studies. International crews with the participation of cosmonauts from Mongolia and Romania worked together with the "Soyuz T-4" cosmonauts within the framework of the Intercosmos program.

Since the date of its launching on 29 September 1977, five main crews and eleven visiting crews have worked aboard the "Salyut-6" station. The station has been manned for a total of 676 days. Repair and maintenance operations made it possible to increase the service life of a number of onboard systems of the station and significantly lengthen its period of active functioning. In the course of implementation of the operational program there have been 34 dockings with manned and automatic spacecraft and three walks into open space. Nine international crews have visited the station in the period from March 1978 athough May 1981. The planned program of joint research and experimentation prepared by the member countries of the Intercosmos program has been fully completed.

The flight of the "Salyut-6" orbital scientific station is an important landmark on the path toward the creation of permanently operating manned scientific research complexes.

CSO: 1866/136-P

BREZHNEV COMMENTS AT COSMONAUT AWARDS CEREMONY

Moscow PRAVDA in Russian 18 Jun 81 p 1

[Excerpt] "I read in one of the newspapers that the cosmonauts speak with regret about the completion of the program. The "Salyut-6"--"Soyuz" complex did extremely well. I can understand such sentiments. But our space science has more complex tasks ahead. Now we must take the next step -- to move on to the creation of permanently operating orbital scientific complexes with replaceable crews. In a word, there is more than enough work for our cosmonauts -- exciting and very necessary work."

CSO: 1866/137-P

TASS REPORTS DOCKING OF 'COSMOS-1267' WITH 'SALYUT-6'

Moscow PRAVDA in Russian 20 Jun 81 p 1

[Text] At 1052 hours Moscow time on 19 June 1981 the "Cosmos-1267" artificial earth satellite was docked with the "Salyut-6" orbital scientific station which at present is in flight in automatic mode.

The "Cosmos-1267" artificial earth satellite, which was inserted into near-earth orbit on 25 April 1981, is intended to test systems and elements of design for future space apparatus and also to develop methods of assembling orbital complexes of large dimensions and mass. In the time that has elapsed, the operating capacity of the satellite's apparatus has been checked in various automatic flight modes, including correction of flight trajectory and other dynamic operations.

According to telemetry measurements, the orbital parameters of the "Salyut-6"--"Cosmos-1267" complex are:

--apogee, 377 kilometers;

--perigee, 335 kilometers;

--period of revolution, 91.4 minutes;

--inclination, 51.6 degrees.

The onboard systems of the station and the satellite are operating normally. The information coming into the Flight Control Center is being processed and studied.

CSO: 1866/138-P

ADVANTAGES OF LONG-DURATION SPACE FLIGHTS

Moscow SOVETSKIY VOIN in Russian No 8, 1981 pp 28-29

/Article by N. Novikov, engineer: "An Extended Expedition"/

/Text/ The creation of the "Salyut-6"-"Soyuz"-"Progress" orbital scientific complex in the Soviet Union made it possible to carry out a whole series of extended manned flights -- 96, 140, 175 and 185 days. These flights gave us rich experience in organizing permanent settlements in space and afford us the opportunity of talking about the special features of space flights of long duration.

As is well known, a huge amount of different materials is consumed in the process of the vital activity of the crew on board an orbital station. The primary ones are food for the cosmonauts, water for drinking and domestic needs, moving picture and still photographic materials, and fuel for the propulsion system. The regular operation of a number of systems in the station also means periodic replacement of system elements such as cleaning filters, harmful impurity absorbers and oxygen regenerators.

In the expended materials we should also include station equipment that has used up its service life, scientific instruments that need replacing, all the different kinds of packaging in which materials and instruments are delivered into orbit, and the air reserves used up every time garbage is disposed of through the airlocks and the crew ventures into space, as well as many other things. Calculations show that the total amount of materials consumed reaches tens of kilograms "per capita" per day. It is obvious that for flights lasting several months, to say nothing of a year, it is impossible to take the necessary reserve of materials to the station in one trip. It is necessary to organize continuous material and technical supply of the station and its crew by using special cargo ships.

In the creation of a cargo ship, one factor taken into consideration was that the amount of cargo delivered into orbit was tens and even hundreds of times greater than what was returned to Earth. As is well known, the only things returned to Earth are those that are the purpose of the flight: moving picture film and still photographs, space smelting samples, containers with biological objects, entries in observation journals. These things weigh only tens of kilograms and can be delivered to Earth along with the crew in a manned ship's descent vehicle. Consequently, cargo ships do not have to return to Earth.

Thus, they are unmanned and nonreturnable. And thus appeared the "Progress" transport cargo ship, created by Soviet scientists, engineers and workers. The lack of

a crew on this ship made it possible to increase its useful load considerably. It was not necessary to carry cosmonauts and their pressure suits and it was not necessary to have reserves of food, water and air. The fact that the "Progress" ships would not return to Earth made it unnecessary to include descent systems: a powerful heat shield, parachutes, engines for a soft landing. As a result, a "Progress" ship now delivers up to 2,300 kilograms of useful cargo to a station, whereas a manned "Soyuz" can deliver only about 50 kilograms.

The extended operation of the "Salyut-6" means primarily experience in working with extraterrestrial technology and the development of methods for maintaining an orbital station and carrying out various repair operations. The members of the most recent "Salyut-6" expeditions -- L. Popov and V. Ryumin, as well as L. Kizim, O. Makarov and G. Strekalov -- performed complicated tasks that would have been impossible 3 years ago when operation of the "Salyut-6" had just begun. Soldering was performed successfully under conditions of weightlessness, metals were cut with a standard hacksaw (and the dangerous metal filings were collected), and the cosmonauts even opened up the sealed hydraulic system, with its toxic working body.

Replaceability and repairability of the on-board equipment is an extremely important feature of an orbital station that is in operation for a long time. Therefore, the designers think about ways of improving these indicators substantially. Now they are inclined to think that the replacement of on-board equipment requires less time and physical effort if all the equipment is placed not along the walls of the station, but along its axis. Such an arrangement will not only increase the convenience of maintaining the instruments, but will also make it possible to create a system for monitoring and eliminating possible disruptions of the station's airtightness as the result of meteorite strikes.

And how does a cosmonaut feel on a flight when, for many months, he finds himself under conditions of weightlessness and a limited living area, far from his normal terrestrial living conditions?

The very first extended flights into space showed that many things that do not attract a cosmonaut's attention on a short flight begin to perturb a crew during longer ones. The sources of such concern can be the constant vibration, noises from functioning blowers and relays, monotony and many other factors. Things that at first glance are very petty can be a source of irritation and subsequent psychological frustration. Therefore, questions relating to the organization of the cosmonauts' daily life and leisure, as well as the daily routine and the work week, are at the center of attention of engineers, methodologists and physicians in many specialties.

Doctor A.D. Yegorov, the space flight medical support supervisor, singles out three factors that facilitate the creation of a good microclimate on board an orbital station and sustain a high physical tone and ability to work, thereby contributing to the successful completion of an extended flight into space.

The first of these is a rationally organized daily life, with an alternation of work and rest periods. All the "Salyut-6" crews have lived on common Moscow time, with a precise work week. Their working day began at the same time it did for Muscovites. They had 9 hours for sleep and 2.5 hours for eating, with about the same amount of time spent on physical exercise. Full value and diversity of the

food rations is an extremely important factor, because any product -- no matter how good it is -- quickly becomes boring.

The second factor is a system of measures for psychological support of the crew. A special group, with the assignment of being concerned about the crew's psychological state, was even created at the Flight Control Center. It is a well known fact that a person has many contacts on Earth. A significant part of them take place in full accordance with a person's wishes and, as a rule, after such encounters his frame of mind improves. For an orbital station's crew there are practically no chances for such intercourse. And so, during the course of the extended flights on the "Salyut-6" we became witnesses of periodic meetings between the cosmonauts and their families, writers, artists and athletes, as well as conversations with friends and scientists. There was television on the "Salyut-6," and now cosmonauts can see as well as hear to whom they are talking; that is, the effect of direct intercourse is created. The communication sessions with the cosmonauts began to be accompanied by music. The assortment of phonograph and video recordings and the book and film libraries on the station were expanded. Sporting events and concerts were transmitted to the cosmonauts. They were particularly happy with the mail, fresh fruit and vegetables, messages from friends and special editions of newspapers that were sent them on the "Progress" ships. Finally, nothing could compare with the effect on the station's basic crew's morale of a visit by other crews, of which well known people from Zvezdnyy Gorodok or the design office were usually a part.

Finally, the third factor is a complex of prophylactic measures aimed at preserving the crew's health and physical tone. The system of physical loads utilizing training-loading suits, vacuum chambers, muscle exercise equipment, a running track and a veloergometer, which was installed to make up for the deficit in muscle activity on the part of cosmonauts in weightlessness, has justified itself completely.

Of considerable importance for a successful flight is the system for training the crew on Earth, in which the crew prepares itself for a flight of a certain duration, as well as the system for selecting the cosmonauts and making up the crew with due consideration for the individual psychological qualities of the future members of a single crew.

In letters to the editors, readers ask if extended expeditions are really necessary. Actually, on a long space flight a considerably part of the crew's working time is spent on physical exercise, which naturally reduces the overall value of the scientific research. And the flight itself is a serious test for the participants in it. However, there is another factor that has not been taken into consideration. During the first multimonth flights of Soviet cosmonauts on the "Salyut-6," fundamentally new opportunities for orbital research were discovered. These included, for example, making visual observations of the land and water surface. It was discovered that the first time a cosmonaut's eye merely "takes in the area," then adapts to the objects being observed, and only then begins to distinguish the details of phenomena and notice the special features of the processes being observed. This is what V.A. Lyakhov, a participant on the 175-day expedition, has to say about this: "Although the ocean's surface seemed at first to be monotonously homogeneous, after half a month we began to differentiate the characteristic shades of one sea or another and different parts of the world ocean. We were astonished to discover

that during a flight, it's as if a cosmonaut learns how to see all over again. At first the finest nuances of color elude you, but gradually you feel that your vision is sharpening and your eyes are becoming better, and all of a sudden the planet spreads itself before you with all its unique beauty."

It is not difficult to what the importance of such a fully "aware" view can be for many terrestrial affairs. Another extremely important factor here is the possibility of the same objects being observed over an extended period of time (during seasonal changes, for example) by the same observer.

USSR Pilot-Cosmonaut L.I. Popov thinks that a lengthy flight has a positive effect on the conduct of scientific experiments when it is necessary to gather statistics and expand the observational material in order to derive more confident conclusions. A prime example of such work is astrophysical investigations, where it is necessary to make periodic observations over an extended period; another is medicobiological research, where the develop of several generations of living organisms is followed or a complete plant development cycle, from seed to seed, is observed during a single flight.

And how, except for a protracted flight, can we solve the problem of the limits of the effect of spaceflight factors on the human organism, on the answer to which depends not only our concepts of the physical possibilities of man, but also the search for ways of penetrating farther into the Universe?

An extended space flight makes it possible to alter the crew's assignments repeatedly and reproduce experiments under changed conditions; that is, to make the research program more flexible and comprehensive. The economic side of the matter also speaks in favor of extended flights: they require fewer expensive spacecraft and everything that is related to their launching and maintenance.

The "Basic Directions for the Economic and Social Development of the USSR for 1981-1985 and the Period up to 1990" provide for the further study and conquest of space in the interests of the development of science, technology and the national economy. This work will be done along many lines. One of the most significant and practically important areas is the study of this country's natural resources from orbit. Photographs taken from orbital stations and manned ships and images transmitted from meteorological satellites have proved to be extremely valuable for geology, agriculture, forestry, fishing, road construction and other branches.

There is practically no branch of the national economy for which the conquest of space would not be useful to some extent. In some branches the use of space information promises truly revolutionary changes. Moreover, the development of cosmonautics is now giving birth to new technical fields that in time can become powerful branches of space production.

The final goal of space flight is that man will be permanently active in space for the good of mankind, and the path to this leads through the extended functioning of crews in orbital stations and through long-term expeditions.

11746
CSO: 1866/127

STUDY OF NONCORROSIVE PROPERTY OF LUNAR IRON

Moscow PRAVDA in Russian 9 Feb 81 p 7

[Article by V. Gubarev: "The Secret of Lunar Iron"]

[Text] This is some kind of psychological drama! Events take place which are not understood and you fret, and you worry, and the outcome is unknown," Aleksandr Pavlovich fell silent, and bent over the lunar panorama, just transmitted from the Mare Imbrium. "Friable soil," he said, "You see, what a clear furrow," and the academician smiled that trusting and happy smile which was so characteristic of him.

Keldysh came into the room. Aleksandr Pavlovich handed him the panorama.

"Take a look, Mstislav Vsevolodovich, what beauty!"

"And the iron?" asked the President.

"Signalite, as always," answered Vinogradov. . .

They continued the conversation, which had obviously started when they were still in the aircraft flying to the Deep Space Communications Center.

The academicians remain for a long time in the room where the data on the composition of the lunar rock came in. They questioned the designers of the instrument installed in the lunar vehicle about the data which was received over the past weeks of operation.

And shortly afterward, at a session of the Presidium of the USSR Academy of Sciences, the President assigned the group of researchers the task of carefully looking into the secret of lunar iron.

"If we are successful in understanding those processes which lead to the appearance of such forms of iron," he said, "and then learn to reproduce them under earth conditions, then we may obtain quite unexpected results."

The group of scientists, who represented various scientific organizations of the nation was headed by the then director of the Institute of Geochemistry and Analytical Chemistry of the USSR Academy of Sciences, Academician A.P. Vinogradov.

". . . He loved to be in the lunar laboratory of his own institute. He would stop at the chamber and look in the observation window. He would look for a long time at the tray with the soil brought from another world. What he did he think and dream of? It is hard to say . . . Aleksandr Pavlovich was a fascinating man, and there was always something interesting to talk to him about."

"Break away from the captivity of standard ideas," Vinogradov paced around the office, "Science is primarily the art of thinking, and if it is an art, this means emotions, feelings, experiences. . . the drama of ideas - this is a precise statement of a scientist's work! We are experiencing something like this now, since we have come up against some phenomena which are not understood. This lunar soil proved to be not so simple as was imagined. . . very interesting. Very!"

. . . Several years passed. In the same building where we saw the soil from the moon for the first time which had been delivered by the automated "Luna-16" station and where we talked with A.P. Vinogradov, I met with the scientists whose work was distinguished with an award for the discovery. The academician A.P. Vinogradov, who is no longer with us, was among its co-authors.

And the conversation which had started long ago continues.

"Aleksandr Pavlovich even laughed at us," recalled doctor of the chemical sciences V.S. Urusov, "when we reported to him that the instruments detected the presence of extremely small metal particles in the particles of lunar soil, in the regolith! It does not oxidize and it does not burn, although it has been in the open air for almost four months now. "A mistake," said Vinogradov, "Check again and find the error."

The academician fairly often joked at his colleagues' expense: they say you don't know even the elementary things such as, for example, can iron even in such a finely divided state not burn?! Vinogradov got his way: the vanity of the chemists was stung, and they repeated the experiments again and again. And the lunar soil "signaled" with the same insistency that the unoxidized metal was still present in it.

This was no longer a joking matter!

The general picture was imagined to be as follows: there is lunar iron; it coats the majority of the lunar soil surface with films (thinner than one tenth of a micron!), but if it is removed from the chamber which simulates the conditions of space, then it immediately oxidizes. But reality gave evidence of something else: even in a terrestrial atmosphere, the iron brought back from the moon did not rust.

The strange behavior of the regolith became known in the Presidium of the Academy of Sciences. M.V. Keldysh, who keenly sensed something new in science,

ordered that the lunar soil be unstintingly used in research. He assisted in drawing upon the efforts of physicists and instrument makers.

"X-ray and electron spectroscopy makes it possible to analyze the composition of the films," explains V.S. Urusov, "And to simultaneously study the various processes occurring in them, including oxidation. The design of the equipment for the research was a very difficult matter and several research institutions participated in our work. We had the closest cooperation with the scientists of the Institute of General and Inorganic Chemistry imeni N.S. Kurnakov, headed up by academician N.M. Zhavoronkov and doctor of chemical sciences V.I. Nefedov. And thereafter, a group of scientists under the supervision of corresponding member of the USSR Academy of Sciences, V.L. Barsukov, was included in the work, where this group included staff members from the Institute of Geology of Ore Deposits, Petrography, Minerology and Geochemistry of the USSR Academy of Sciences and the Institute of Metal Physics of the Ukrainian SSR Academy of Sciences. They discovered unusual forms of not just iron, but also titanium, silicon and possibly, aluminum in regolith. We had come up against an extremely interesting problem."

And so, the fact was established: there are iron, titanium, aluminum and silicon in lunar regoliths which do not oxidize in a terristrial atmosphere. The iron advertized itself the loudest and it remained to be ascertained what allowed it to be preserved on the earth, and finally, would it not be possible to use this suprising property for practical needs.

The solar wind . . . Haven't the scientists found a poetic name for the stream of particles carried away from our star? It is specifically this wind which will assist future space caravelles in traveling in space: there are almost fantastic plans for such "sailing craft" for the universe. But in our story, the solar wind plays quite a different part - it becomes a metallurgist.

The regolith covering the surface of the moon is a mixture of rock debris, minerals, glasses and sintered materials formed with the action of the meteorite rain and the charged particle flux. And in order to explain how the iron appeared, all of the factors must be taken into account. Let us suppose that an iron meteorite strikes the surface of the moon. There is an explosion. The meteorite vaporizes and the matter then begins to condense. Can iron appear in this case? Without doubt. And the evidence of this is the lunar glasses and sintered materials where the greatest concentration of unoxidized iron is noted. Now, about the solar wind, and more precisely, about the protons which are found in it. In one case, they eject volatile elements from the surface of the iron and reduce the amount of oxygen in it. This is, so to speak, the "physical" action of the solar wind. But chemical processes also take place in the regolith, and they probably play the decisive role.

We shall try to explain the mechanism for such a transformation. In simplified terms, the scheme is as follows: protons are introduced into the regolith grain,

and interact with the oxygen, water is formed and then it flies out into space in the form of individual molecules. Speaking in general terms, it is as if the lunar compounds decay into constituent parts - for there is no oxygen which combines with the metals. And both microdrops are formed as well as thin films. This process is facilitated by the fact that in the course of the constant bombardment by micrometeorites, the lunar surface is heated up . . .

The theory, which is quite convincing, requires an experimental check. In order to demonstrate to what extent the calculations are true, it is necessary to simulate lunar conditions in earth laboratories and to obtain the same iron, the formation of which is so unusual.

Terrestrial basalts are similar to lunar rock. They were taken as the subject of the experiments. However, enormous difficulties stood in the way of the researchers. A vacuum, which was successfully produced in the installations, became contaminated instantaneously. The scientists were successful in obtaining only an insignificant amount of the "lunar" iron.

The simulation of the action of the solar wind on the metal was begun. Plates were subjected to an intense attack by argon ions. The corrosion resistance of the metal was increased.

These were the years of searches and doubts, successes and disappointments. And samples of regolith lay in the laboratory which were brought back in 1970 by the "Luna-16", and thereafter by the "Luna-20" and the "Luna-24". Months and years passed, but the unoxidized iron content in them did not decrease. And this mute representative of the moon forced the search for approaches to the secret.

Doubts arose: maybe everything was enormously simpler? And if pure terrestrial iron is taken, will it also not oxidize under these conditions?

Thin plates of ultrapure iron were fabricated. Their surface was carefully polished. But very little time elapsed and it turned out that the plate was coated with a thin layer of oxide. While the lunar iron remained stable just as before, as if it were not on the earth. . .

"Most likely, we would have been able to get final results earlier," said V.S. Urusov, "If we had had the capability of performing experiments in space, on board space stations or satellites. Nature operates in an extremely pure vacuum, and it is extraordinarily difficult to reproduce it in laboratories and simultaneously experiment in it. However, many years of research by a large staff nonetheless helped to overcome, it would seem, the insuperable obstacles. We determined why and in what fashion the lunar iron is produced. There are no oxidation centers in it, while the corrosion process is literally a chain reaction: it just has to get started at one point, and then it spreads throughout all the metal. Our experiments showed that the corrosion resistance can be improved if they are treated with ion beams."

Here in front of us is a stainless steel disk. On it is written "Luna". Only this portion of the disk has been subjected to an attack by an ion beam. Then the scientists placed the disk in vapors of aqua regia, and after 15 minutes it coated with rust, while the word "Luna" shined with its initial purity.

A diploma for the discovery was awarded to a large group of siientists. This was the outcome of what they had done and simultaneously marked the birth of a new field of research. The use of ion beam treatement of metals is quite effective in some fields of engineering, in particular, in electronics and in instrument making. It is as yet early to talk about the widescale application of the technique - the design of the specialized equipment and the search for the new technology is still ahead. It is always difficult to predict the future . . .

It is not out of the question that ion beams, with the course of time will process metal parts in space which are needed for space structures . . .

Well, will metallurgical plants producing "Lunar iron" appear on earth? In principle, it is easier to construct such a plant on the Moon or in space, where there is the requisite vacuum in an unlimited amount, but . . . on the other hand, this is difficult for us, while such construction may prove to be essential to our children and grandchildren and just as customary as the construction of hydroelectric stations is for us today.

A discovery in science is always an echo of the future.

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JOINT DETERMINATION OF ATMOSPHERIC TEMPERATURE AND TRANSPARENCY FROM MEASUREMENTS OF OUTGOING INFRARED RADIATION UNDER CLOUDLESS CONDITIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 17, No 3, May 81 pp 250-258 manuscript received 21 May 79

PETRENKO, B. Z., Institute of Radio Engineering and Electronics, USSR Academy of Sciences

[Abstract] In solving the inverse problem of recovering the atmosphere's vertical temperature profile on the basis of measurements of outgoing infrared radiation, one of the problems is separating the contributions of variations in temperature and transparency to the radiation. Under cloudless conditions, variations in transparency are caused mainly by water vapor and aerosol. The author formulates the inverse problem, presents a method for solving it, and then proceeds to a joint determination of the temferature profile and the aerosol transmission function. The basic results of his work are: within the framework of a statistical approach, he has developed a method for determining the vertical temperature profile and the temperature of the underlying surface for a turbid, cloudless atmosphere; he has demonstrated the possibility of an effective separation of the contributions of variations in transparency and temperature to outgoing radiation in connection with joint measurements in the 4.3 and 15 μm carbon dioxide absorption bands. Figures 2; references 13: 12 Russian, 1 Western. [106-11746]

UDC 523.42:551.576.11

MODELING THE OPTICAL PROPERTIES OF VENUSIAN CLOUDS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 17, No 3, Mar 81 pp 243-249 manuscript received 10 Oct 79

KONDRAT'YEV, K. Ya., MOSKALENKO, N. I. and TERZI, V. F., Main Geophysical Observatory

[Abstract] Using data gathered by the "Venera-8," "Venera-10," "Venera-11," "Venera-12" and "Pioneer-Venus" interplanetary stations, the authors discuss the optical characteristics of Venusian clouds and their separate components (primarily

CO_2, with small admixtures of H_2O, CO, HCl, NH_3, N_2 and SO_3): attenuation, scattering and absorption coefficients and scattering indices. They present a detailed discussion of the optical density of Venusian cloud cover, the basic components of which are liquid H_2SO_4 and particles of solid and liquid sulfur. Comparing the available data with two cloud cover models corresponding to planetary albedoes of 0.74 and 0.77, they conclude that the latter is more probably correct. Figures 4; references 21: 17 Russian, 4 Western.
[108-11746]

UDC 524.35

GAMMA-BURSTS OF 4 NOVEMBER 1978 AND 6 AND 18 APRIL 1979, AS REGISTERED BY THE 'VENERA-11,' 'VENERA-12' AND 'PROGNOZ-7' AUTOMATIC INTERPLANETARY STATIONS

Moscow PIS'MA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 7, No 1, Jan 81 pp 20-25
manuscript received 26 Jun 80

ESTULIN, I. V., D'YACHKOV, A. V., ZENCHENKOV, V. M., KUZNETSOV, A. V., MERSOV, G. A., VEDREN, Zh., NIEL', M. and KHARLI, K., Institute of Space Research, USSR Academy of Sciences, Moscow, and Center for the Investigation of Space Radiation, Toulouse, France

[Abstract] The three gamma-bursts had different temporal patterns and were different types of surge events. All three were registered by all three spacecraft. The authors give detailed descriptions of the energy level, temporal characteristics and other elements of the flares, then try to match them with actual stellar objects, but without success. The burst of 4 November 1978 came from the area of the constellation Capricorn, while those of 6 and 18 April 1979 came from the areas of the constellations Crane and Orion, respectively. Figures 5, references 13: 7 Russian, 6 Western.
[101-11746]

UDC 523.3

SUMMARY OF RESULTS OF PHOTOMETRIC INVESTIGATIONS OF THE FAR SIDE OF THE MOON

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 15, No 1, Jan-Mar 81 pp 3-10
manuscript received 24 Oct 79

PSAREV, V. A., Astronomical Observatory, Khar'kov State University

[Abstract] The author summarizes the results of the analysis of photographs of the far side of the Moon taken by the "Luna-3" (October 1959), "Zond-3" (July 1965), "Zond-6," "Luna-20" and "Zond-8" (October 1970) automatic stations and "Apollo 12-17." The basic difference between the near and far sides of the Moon is the absence of maria on the latter side. The far side of the Moon has not yet been studied with any great accuracy, since the pictures used were taken when photometric

surveying from space was still in its infancy. The author proposes a series of experiments that will give a better idea of the actual nature of the Moon's invisible side. References 27: 22 Russian, 5 Western.
[85-11746]

LIFE SCIENCES

PROSPECTS FOR TERRESTRIAL BIOLOGY IN SPACE

Moscow ZEMLYA I VSELENNAYA in Russian No 1, Jan-Feb 81, pp 18-23

[Article by Academician O. G. Gazenko, Candidate of Biological Sciences G. P. Parfenov and Doctor of Medical Sciences Ye. Ya. Shepelev]

[Text] Biological experiments in space indicate that weightlessness is compatible with the normal vital activity of the organism, but it imposes special requirements on scientists when preparing and performing experiments.

Biological Evolution

The well-known American geneticist S. Spiegelman, who is famous for the fact that viruses were synthesized from inanimate material for the first time in his laboratory, noted jokingly: "DNA invented man in order to propagate itself beyond the limits of the earth." The latest achievements in the conquest of space by man lend serious meaning to this joke. Indeed, the DNA (desoxyribonucleic acid, genetic information carrier) of man or any other organism can be carried beyond the limits of the earth only by engineering means built by people. There are probably no other ways of propagating life within the solar system.

According to the current ideas about the origin of life, for firectional evolution of its cellular forms environmental conditions are needed which are limited to a narrow range of temperatures and other physical factors. In addition, the environment must contain the building blocks of DNA and proteins and the substances capable of "making small change with the energy factors of the organism" -- the phosphate groups.

The appearance of a solid surface turned out to be necessary in a defined phase for evolution of the organisms. Nevertheless the first steps toward the occurrence of life possibly were taken not on the planets, but (much earlier and in much larger spaces of the galaxy) in the interstellar clouds where very severe physical conditions predominate and in practice there is no gravity. The recent hypothesis of prebiological evolution (F. Hoyle is one of its active proponents) is of interest in

that the commonness of all life in the galaxy necessarily follows from it. In addition, within its framework the evolutionary process has much more time and space. Of course, the hypothesis does not exclude the possibility of local prebiological evolution on individual planets, for example, in accordance with the ideas developed by A. I. Oparin. After disintegration of the first-generation stars, the composition of the interstellar clouds had all of the necessary elements for the formation of the substances that were the predecessors of life: hydrogen, carbon, nitrogen, oxygen and metals. The thermal conditions in the interstellar clouds permit the formation of complex organic molecules -- amino acids, sugars and aldehydes. The joining of the molecules into interstellar dust provided their valence bonds sufficient protection against ultraviolet radiation. Wandering through the expanses of the galaxy, the dust with the organic molecules ran into a variety of conditions. What might be called the analog of Darwin's evolution unavoidably began -- the survival and development of the most adaptable, stable, long-lived forms.

The possibility is not excluded that the natural vehicle for transporting the substances that were predecessors of life from the depths of outer space to the surface of the planets was the comets. Picking up the organic molecules in interstellar space, the comets carried them to their homes -- the planets. If the home turned out to be hospitable, biological evolution began. Otherwise the planet became lifeless.

The steps in biological evolution are well-known at the present time, although the details are unclear. The fact is that the intermediate links between the basic groups of organisms, for example, prokaryotes and eukaryotes[1] disappeared irreversibly and without a trace -- they were swept away by natural selection. However, it is necessary to note that there is an unquestioned, firmly established and direct biological relationship between such prokaryotes as bacteria or blue-green algae and the eukaryote -- man.

In the modern view, the differences in the genetic composition between organisms are essentially insignificant. For biological evolution it is not the genetic composition that is important, but the structure, the optimal sequence of genetic material, methods of monitoring and controlling it. The commonness of physiological reactions of organisms also indicates the close relationship of all life on earth. Even bacteria have such human characteristics as perception and memory. Perception and memory which are expressed in the manifestation of previous reactions to current, but previously encountered stimuli, insure predominant spread of microorganisms to fresh nutrients.

The question is often debated as to which came first -- protein or DNA? In all probability, the question will remain forever rhetorical... On the other hand, it is possible to state that the relationship of animate forms is established only through the DNA. Therefore (at least for the sake of convenience) it is meaningful to relate the occurrence of life to the occurrence of this substance. After its occurrence, DNA immediately began to organize the environment for optimal acquisition

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[1]Prokaryotes are organisms that do not have a permanent cellular nucleus and the standard chromosome apparatus. The hereditary information is realized and transmitted through the DNA. The prokaryotes include bacteria, blue-green algae, and so on; eukaryotes have a formed cellular nucleus and the standard chromosome apparatus. They include animals and plants, including many single-celled forms.

of the energy needed for its own multiplication. The directions of evolution related to each other appeared. One of them -- the evolution of animals -- led to the origin of man. For a long time it was not understood why DNA needed to "invent" man. With the beginning of space research it became obvious that DNA needed man as an assistant and intermediary for its recurrence extraterrestrially. Or, if we are serious, the conquest of space is not only an intellectual, social and economic necessity, but also a biological need.

In the Absence of Gravity

With what scientific baggage, what hypotheses and prospects have people answered the biological call? It is possible to describe outer space by a number of parameters which are clearly incompatible with terrestrial forms of life. The organized forms of life cannot survive prolonged stays in a vacuum, temperatures that are too low or too high or intense ultraviolet radiation. These three factors are unfailing characteristics of outer space. It is possible to penetrate outer space only if living beings are protected from the lethal effects of space, that is, in the customary habitat environment for terrestrial organisms which spacecraft carry with them. In addition, the flights of spacecraft usually take place in the free fall condition in which a state of dynamic weightlessness occurs. If we consider that organic evolution, beginning at least with the origin of the cell, took place under conditions of constant gravitational force, a legitimate question arises: how do terrestrial organisms behave under conditions of weightlessness? Since the first space experiments (as early as the ballistic missiles) biologists have tried to answer this question.

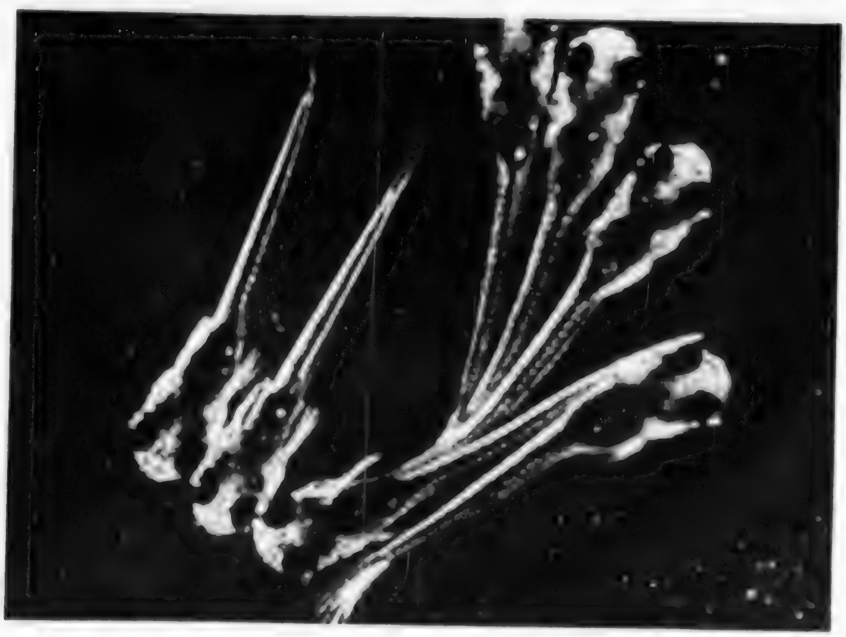
Scientists have already performed several tens of experiments with free-living single-celled organisms -- both prokaryotes and eukaryotes -- which have demonstrated that weightless has no effect on the behavior of the individual cell -- neither the reproduction rate nor the energy processes and, in all probability, the mutagenesis processes are altered. It must be stated that microorganisms react very sensitively to the cultivation conditions, and weightlessness is one such condition. It influences the cell distribution in the medium, the concentration gradients of the nutrients, and the ratio of the liquid and gas-phase interfaces.

As a rule, weightlessness creates more favorable conditions for the cultivation of microorganisms; therefore, between earth and space experiments, the difference is in favor of space experiments. This holds true, of course, only when the remaining cultivation conditions are maintained at the required level: the concentration of the medium, the temperature, and for aerobics, aeration. However, the theoretical interest of researchers has been concentrated primarily on the behavior of an individual free-living cell under weightlessness conditions. We consider that the experiments have provided a unique answer: its properties, functions and morphology remain unaltered.

This is how it turned out, for example, in the experiments with the single-cell algae, chlorella which initially favored the idea of acceleration of their growth under weightlessness conditions. In recent experiments this apparent effect came to be explained by the peculiarities of the liquid distribution with respect to the wetted surface of the algae cultivator under weightlessness conditions, as a result of which the area of the gas-liquid interface was increased significantly. This improves the conditions of the gas metabolism of the algae and insured a high growth rate. A physically adequate experiment (with reproduction of the increased phase contact area) demonstrated the absence of noticeable difference in the growth rate of algae in space and on the earth.

The presented example again demonstrates that it does not pay to hurry the explanation of the results obtained by the primary biological effect of weightlessness until the secondary derivative effects connected with different biotechnological conditions have been excluded. This pertains all the more so to failure to observe ordinary mandatory conditions of cultivating the organisms (which was discussed earlier) not having any relation to gravity.

Fewer experiments on a smaller number of species were performed with the multicell animals under weightlessness conditions. In order to study the general biological problems -- the development, multiplication, survival rate and mutagenesis -- as should be expected, insects have turned out to be the most suitable. At various times in the last two decades three species of insects have been used: fruit fly most often, the flour beetle less, and one experiment was performed on an ichneumon fly In many cases the duration of the experiment made it possible to obtain two and even three generations of fruit flies under weightlessness. The results of the experiments with fruit flies confirmed by studies and two other species of insects turned out to be quite unique. Weightlessness had no influence on reproduction, morphology, anatomy, biochemistry or even behavior. In a word there was no effect on anything that was studied. In one of the experiments with fruit flies it was precisely established that the fruit fly and apparently many other species of insects do not react to gravity, in any case within the range from 0 to 2 g. The vitality, capacity for reproduction and many other indexes were identical; no characteristic was altered by which it was possible to judge that the fruit fly noticed whether it was living with weightlessness, at 1 g or 2 g.



Thirty-day old fry of the aquarium fish fundulus developed under weightlessness. It is obvious that all of the fry are normal.

A large experiment was run to discover the effect of weightlessness on the embryonic development of animals, primarily amphibians and fish. Since the end of the last

century, after the experiments by the German scientist E. Pflueger, it has been generally accepted that for many of the animals gravity determines the egg distribution in the zones with different morphogenetic possibilities. The study of embryonic development directly under weightlessness revealed no significant morphological disturbances, including disturbances of the development of the organs of balance. At the present time something has been explained about the question of the effect of gravity on embryogenesis. Some experiments permit the assumption that for normal development animals do not need gravity, but some compensation for it. But if there is a need for compensation for gravity for normal development, then under weightlessness conditions there should be no interference with development.

The last of the embryological experiments was run with quail eggs in which the initial phases of embryogenesis took place during the period of formation of the fertilized egg, and therefore are not subject to ordinary experimental analysis. However, incubation of these eggs under weightlessness conditions for 75% of the embryogenesis period did not indicate changes in the embryonic development processes which differed significantly from the results obtained under terrestrial conditions.

There is no doubt that for large vertebrates, especially land vertebrates, gravity acts as a shaper and, in addition, controls their size. However, gravity also determines the size and shape indirectly. The direct cause is natural selection and the genetic systems controlling development created by it. These genetic systems, of course, do not change under weightlessness, at least, for a surveyable number of generations. However, the genetic reaction norm can change. It is known that the norm is a series of states. The range of states can vary, but within its limits all the states remain normal. Let us mention that at the present time the average height of an adult male is 173 cm, but heights of 160 and 190 cm are within the norm.

There are reasons to think that the external appearance and functional characteristics of vertebrates and, of course, man, can be altered on birth and development under weightlessness. For example, the vertebrates assume a more "embryonic" form as a result of insufficient load on the extensors.

There is still no general satisfactory theory of the effect of gravity on the development of organisms. Efforts are now being concentrated on experimental studies of the empirical determination of the reaction norm. These studies are being performed on biological satellites, in centrifuges and clinostats. The clinostat is an apparatus which rotates the subjects around the horizontal axis and at the same time compensates for the constant gravitational effect. Many experimental results are unexpected. In scientific literature it is possible to read about any effects of gravity. This situation is characteristic of the initial period of study of the problem in the absence of a general theory.

One of the reasons for which in related species the small animals survive the experiments with alteration of gravity better is that in large animals the margin of strength is significantly less. This is determined by the global evolutionary strategy. Promoting an increase in size of the animals of the same group, evolution tries to do this as economically as possible; therefore the building material is not up to a large margin of strength. Under natural conditions this does not bother large beasts at all. Their safety is guaranteed not only by the structural strength, but also by increased caution -- the sensory organs and central nervous system have been progressively improved in them. In the experimental situation an improved adaptability of behavior does not help.

The multagenic effect of weightlessness deserves special attention. In space flights mutagenesis has been studied, being oriented toward the entire set of factors of space flights, ionizing radiation and, especially, weightlessness. As a result of various research goals, the conditions of setting up the experiments with different subjects has been such that it is not possible to expect identical or constantly consistent results. There are few experiments in which the mutagenic effect of weightlessness has been specially studied. They are complicated to perform, for it is necessary to exclude the influence of other factors. All of the results obtained are on the whole quite clear; weightlessness is not a strong mutagenic agent and, possibly, does not cause mutations at all.

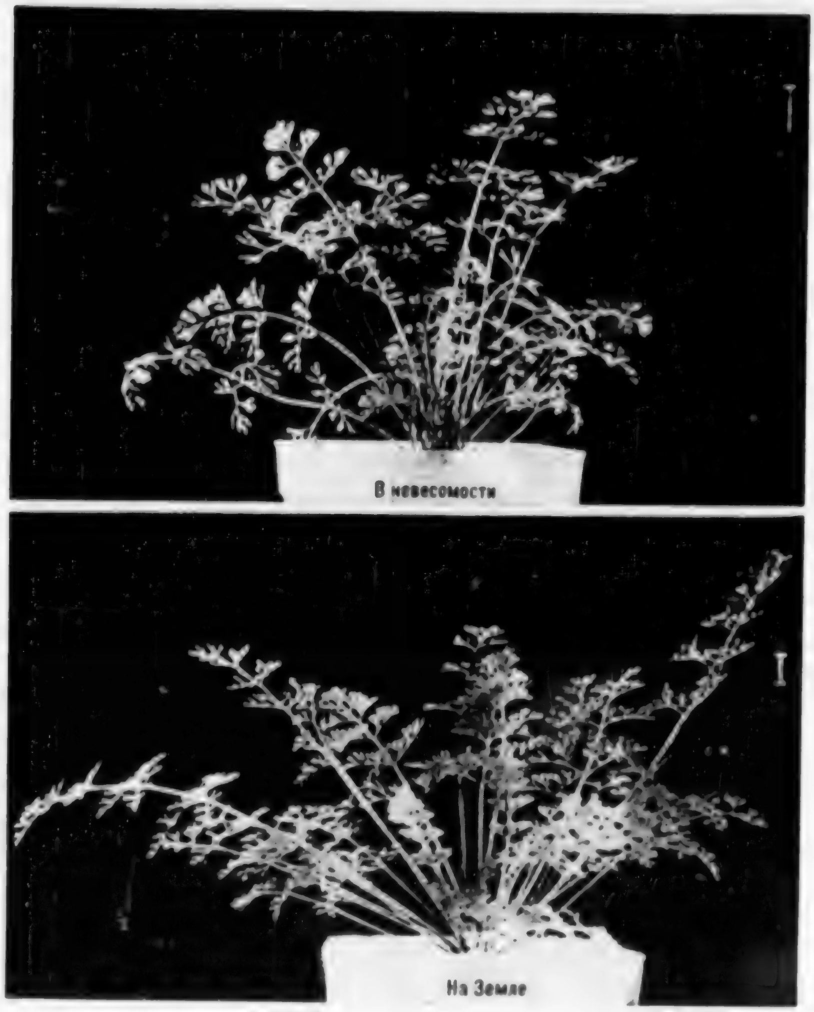
The indeterminacy of our statement is connected with the fact that in some species of animals and plants sometimes an increase in mutation frequency is noted in a series of genetic tests. This primarily pertains to the appearance of cells that have lost or acquired one or several chromosomes in Tradescantia and Drosophila. In itself the increase in mutation frequency is not significant, and it cannot cause alarm. However, of course, the problem requires further study, primarily for exact establishment of the reality of the phenomenon.

Higher Plants under Weightlessness Conditions

The study of higher plants under weightlessness is connected with great difficulties. The fact is that the plants are in closer relation to the entire biosphere of earth than animals. Animals regulate their internal environment quite precisely in the presence of significant changes in the external parameters, for they have a common control center -- the nervous system. Plants do not have such a center. Their development and vital activity take place as a result of what plant physiologists call the "free play of hormones," interacting with invariant succession of the external environment. The sprouting of the seed, growth, flowering, maturing and dying of the plants take place in this way. The critical changes in the external conditions of the plant correspond to evolutionary adaptations which animals do not have -- more varied methods of reproduction, prolonged dormancy of the seeds, as a rule, broader ecologic adaptability. The struggle for existence in the plant kingdom takes place passively. The plants cannot leave an area where living conditions are unfavorable, they cannot demonstrate what displeases them. They react to unfavorable conditions by dying, dormancy, and long-range genetic changes. Even now plants are "awaiting" the time when biologists will begin to perform experiments on spacecraft with them.

The relations of plants to the biosphere, which in a defined sense replaced the internal environment by it, require quite exact regulation of such conditions as temperature, light, moisture, and mineral nutrient conditions when setting up the experiments. On board spacecraft optimal conditions have still not been created for plants. Decisive experiments with higher plants under weightlessness conditions are ahead.

Artificial ecologic systems including man have already been investigated more than once. Even the simplest man-algae model reproduces about 80% of all of the substances needed by man and 100% of the water and oxygen as a result of biological regeneration. If we add higher plants, it is possible to reproduce 25% of the food. The system containing high plants and animals can theoretically provide up to 90 to 95% of the required substances.

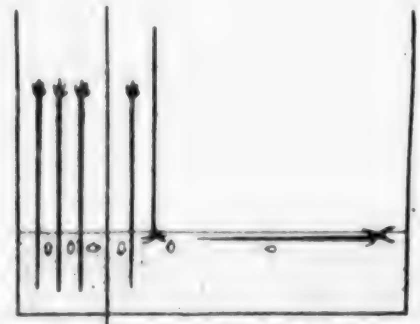


Ordinary plants are grown on the ground from "space" embryos. In the photographs it is impossible to distinguish plants that began development on the earth and those that began on a biological satellite.

Key. a. under weightlessness conditions
b. on the earth

A basic characteristic of models with a closed material cycle is the potential capacity for independent stable existence. Stability is connected with the dimensions of the system -- the amount of animate and inanimate material and the species variety. Biochemical completeness -- closure of the system -- depends on the number of species of animals: plants and microorganisms.

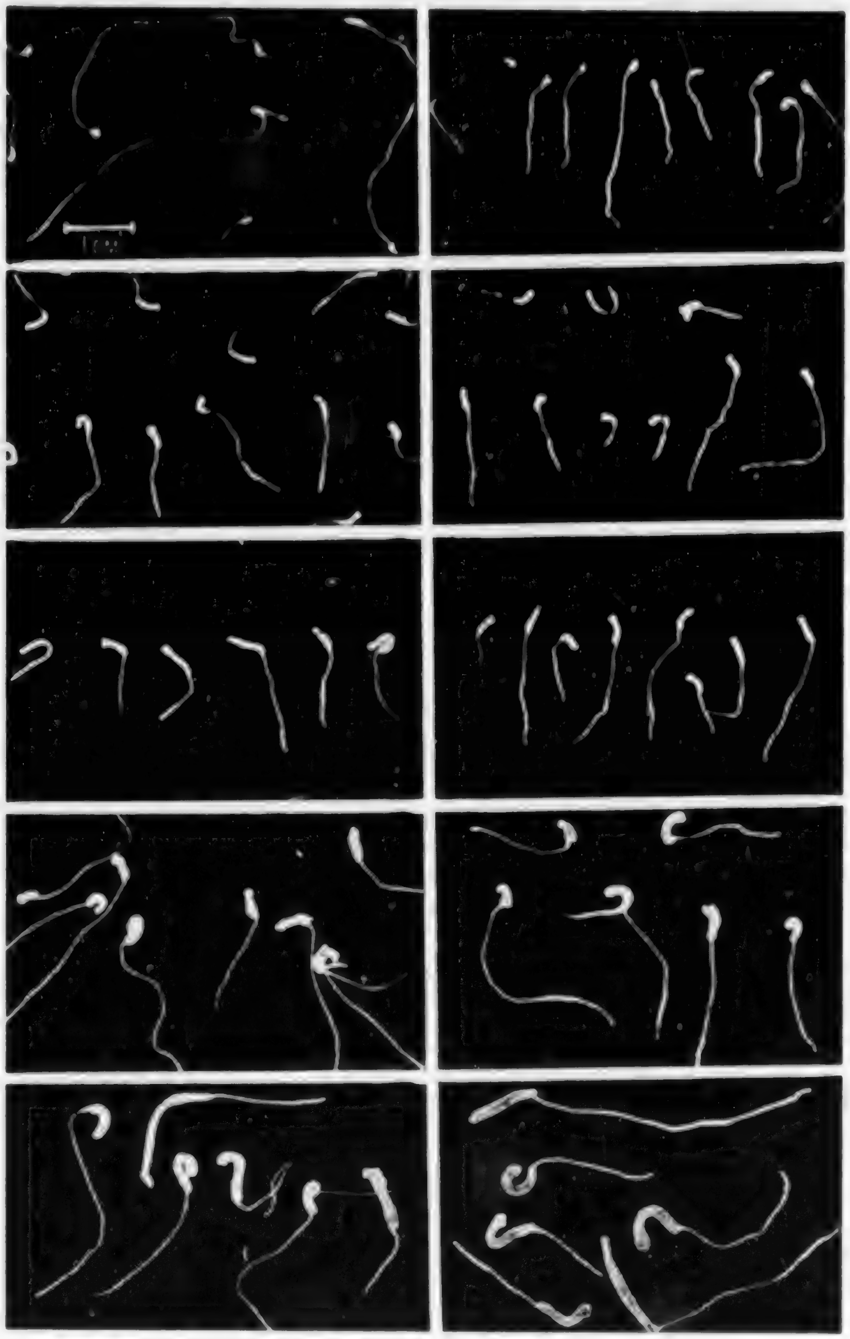
The solution of these two problems -- the minimum volume and minimum number of species -- is the basis for the existence of an autonomous, stable system suitable for practical use. For practical purposes it is sufficient to solve the problem of stability limited by the time of the specific space enterprise.



Orientation of underground and above-ground organs of plants that have been grown on the earth and under weightlessness conditions. In weightlessness the direction of growth of the roots and stems can change. On the earth the roots are directed into the soil and stems into the atmosphere by gravity. Without gravity the roots can grow into the atmosphere and the stems into the soil.

And the last thing is the energy base for the system -- photosynthesis. It requires light energy of a defined range. The influx and use of solar energy will also be a limiting condition.

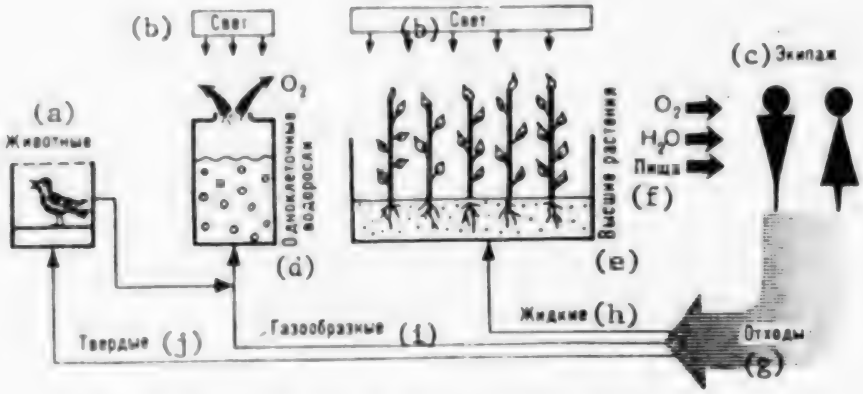
The results of the studies performed at the present time are inspiring defined optimism. The sprouting of dry seed has been studied on many flights. It has been discovered that this process takes place entirely normally. Changes in orientation of the primary (embryonic) organs and the angle between the main stem and the side shoots observed in these experiments were not unexpected. They were predicted more than 100 years ago by the German botanist Julie von Sachs on the basis of experiments using clinostats. The experiments with Tradescantia and Arabidopsis have established that the flowering and maturing of the seed of higher plants, can also take place without disturbance. In Tradescantia weightlessness even stimulated flowering, in Arabidopsis the seeds maturing under weightlessness conditions fell on the substrate (soil substitute) and after the corresponding embryonic pause sprouted on the earth. The embryonic development of the plants from the cell culture of carrots, as experiments demonstrated, were in all respects the same as on the earth. All stages of development of the plants took place normally under weightlessness. Thus, it was established experimentally that the embryonic development of plants, sprouting of seeds, the formation of the primary and basic organs, flowering and, finally, maturing of the seed can take place normally under weightlessness conditions. In plants which grew under weightlessness there were no significant changes in the biochemical composition or anatomical structure. It is true that these processes were studied on different species of plants and in separate experiments, but there is every reason to consider that in the space hothouse created by a competent biological engineering design, normal yield can be obtained under weightlessness. The problem is not at all a simple one, and it is not only a matter of exact regulation of many of the parameters of the environment. It is a matter also of the fact that changes in mutual orientation of the organs and external form of the plants as a result of a decrease in the angle between the main stem and the shoots



Development of cell structure of carrots under weightlessness (on the left) and on the earth. The experiment demonstrated that weightlessness has no influence on the development of the plant.

will possibly require special agrotechnical procedures. The essence of these procedures has still not been studied.

There are technical difficulties, but no serious doubts that with time it will be possible to create an economically advantageous model farm on space or planetary stations. The prospects for creating an extraterrestrial "Noah's Ark" as the



Block diagram of an artificial ecologic system.

Key:
- a. animals
- b. light
- c. crew
- d. single-cell algae
- e. higher plants
- f. food
- g. waste
- h. liquid
- i. gas
- j. solid

experimenters call the stable, entirely autonomous ecologic systems, are much less clear.

When J. Lavstock, the English biologist, studying the problem of the existence of life on Mars in the "Viking" project was asked "Can there be regions on Mars, Venus and Jupiter where life exists?", he answered: "No, a planet, like man, is either alive or dead." According to the presently existing ideas, the earth is an integral live organism on which there are three animal kingdoms -- microbes, plants and animals -- and the external environment is regulated by means of numerous feedbacks interacting with each other. This regulation, of course, is automatic. The stability of the entire system is directly dependent on its dimensions. Is it possible to build a "Noah's Ark" that functions stably and autonomously beyond the earth -- this is a question which only a thorough global study of the biosphere in parallel with stricter quantitative study of the processes occurring in it on experimental models can answer. There is a basis for studies in this area. It has been set up in the science of the biosphere as a whole by V. I. Vernadskiy.

Of the three bases on which the well-being of the evolutionary process depends -- reproduction of the matrix structures (heredity), the occurrence of mutations (alterability) and natural selection -- everything is in order with the first two under weightlessness conditions. These are the facts of experimental space biology. They offer man the possibility of being in space with the biological environment necessary to him for a sufficient time to find the conditions of the advent and support of stabilizing natural selection under weightlessness conditions.

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SPECULATION ON FUTURE DEVELOPMENT OF SOLAR POWER STATIONS IN SPACE

Moscow TEKHNIKA - MOLODEZHI in Russian No 3, Mar 81 pp 4-7

/Article by Professor Sergey Grishin, doctor of technical sciences, and Yevgeniy Narimanov, engineer: "Space Solar Electric Power Stations and the Prospects of Space and Rocket Technology"/

/Text/ The basic advantage of solar energy is not only that its source is practically inexhaustible, but also that ecologically it is completely clean; that is, it does not contaminate the environment with deadly radiation and products that are harmful to every living thing. The scale of the Sun's energy is vast. It is sufficient to say that the light striking the Earth every minute carries an amount of energy equal to that generated by all the electric power stations in the USSR in 1 and 1/2 years.

Solar energy is already being used on limited scales, to (for example) heat water and houses. Hundreds of small solar electric power stations are in operation in the remote regions of our country. They power shore and other beacons and supply energy to meteorological stations and the water-lifting stations that are helping us conquer the deserts. True, the electricity generated by them is more expensive, by a factor of 500 or more, than that produced by thermal and hydroelectric power stations. This has retarded the development of terrestrial solar power engineering substantially. However, the specialists see a possibility of reducing the cost of energy produced by terrestrial solar electric power stations by an order or two of magnitude if considerable effort and material expenditures are applied to the problem. In any case, however, terrestrial solar power engineering will obviously be able to play only an auxiliary role. Solar electric power stations in space are an entirely different matter.

The collection of the Sun's radiant energy, its conversion into electrical energy, and its transmission to Earth for use in the national economy has fundamental advantages in comparison with its collection by terrestrial installations. Among them are an increased level of solar radiation, continuity of the energy production process, the possibility of building structures of great size in space, a reduction in the amount of construction materials used, and a minimum effect on the surrounding environment when the system is in operation. Following K.E. Tsiolkovskiy, who first pointed out these advantages, N.A. Rynin and M.K. Tikhonravov gave considerable attention to the problems involved in mastering the Sun's energy in space.

At the present time, solar energy is used in space to power life support systems and other equipment in spacecraft. Work is being done on the utilization of solar energy to power the electrojet cruise engines of spacecraft intended for flights into areas of interplanetary space that are difficult to reach.

As far as we know, the idea of supplying the Earth with electricity by means of space solar electric power stations (KES) and energy transmission over a radio beam was first proposed by Pilot-Engineer N. A. Varvarov, the well known popularizer of space technology. Two and a half years after the launch of the first artificial Earth satellite, in a series of articles published in TEKHNIKA-MOLODEZHI devoted to the prospects for utilization of spacecraft for national economic purposes, Nikolay Aleksandrovich wrote: " . . . when people learn how to transmit electricity from space to the Earth without wires, in a manner similar to the way radio communications are realized today, man's creative thought will direct his efforts to the creation of space helioelectric power stations that will supply the inhabitants of Earth with electricity in unlimited amounts" (TEKHNIKA-MOLODEZHI, No 3, 1960, page 34).

Later, in work done from 1968 to 1971, the American scientist P. Glazer specified the planned appearance of a KES including a system for directed energy transmission from space to Earth in the superhigh frequency band. He also suggested that electric power stations be placed in stationary orbits. At the present time, Boeing, Rockwell International and the other largest American aerospace corporations are developing engineering plans for KES's and their accompanying ground and space complexes. Radio engineering, electronics and electrical engineering companies are also participating in this work.

Basic Types of KES's

At the present time, the planned appearance of a KES has been basically determined. It will be a large structure having no analogs in the history of space technology. For a useful power of 5 million kW, the mass of a station in a working orbit is estimated to be 20,000-60,000 tons, depending on the method of converting the Sun's radiant energy into electrical energy and the final weight of the power plant and the system for directed transmission of the energy from space to Earth.

The use of the photoelectric method of direct conversion of the Sun's radiant energy into electrical energy on the basis of semiconducting solar elements with 10-20 percent efficiency results in the necessity of collecting a large amount of radiant energy, which entails the construction of solar collectors covering large areas.

The turbine -- or, as it is otherwise called, thermodynamic -- method of converting the energy in solar radiation to electricity with the help of a system consisting of a solar furnace, a turbine and a generator is characterized by the preliminary conversion of the radiant energy into thermal energy. The turbine method's efficiency can be raised to 40 percent or more, which results in a reduction in the surface of the solar concentrator, which is a device that insures the focusing of the solar rays on the heat receiver. As a result of this, the size of a solar electric power station utilizing the turbine method of conversion is quite moderate, although the use of metal-intensive systems -- turbines, radiators, electrical generators -- results in an increase in the power station's weight.

The energy can be transmitted to Earth via a superhigh frequency beam or a laser beam. The first method means favorable conditions for the passage of the beam through the atmosphere, high direct and inverse conversion efficiency, and the possibility of using superhigh frequency instruments that have already been developed and built. The advantages of the laser method are the possibility of forming a narrow beam and the small size of the transmitting and receiving units. In this case, however, the direct and inverse conversion efficiency is not high and, in addition, absorption of the laser radiation by the atmosphere can lead to a lowering of the transmission efficiency to an unacceptable level. On the whole, at the present time the transmission of energy from space to Earth by a superhigh frequency beam is preferable.

The development, assembly, delivery in working orbit and maintenance in space of a KES require the creation of special installation-assembly, aerospace and interorbital transportation and operating space complexes. In combination with the ground receiving station and rectenna (rectifying antenna), the ground control point and the freight and passenger launch vehicles, the accompanying space complexes form a whole system of objects around a KES. The creation of all these complexes is no less complicated a problem than the creation of the KES itself. The key to the solution of the entire problem will be superpowerful freight launch vehicles (RN), with the help of which the KES's elements have to be lifted from Earth into a low orbit. The weight of these elements will range from 100 to 500 tons.

The launch vehicles used at the present time are one-time rockets; this means that after their stages have carried out their mission they fall back to Earth and are irretrievably lost or burn up almost completely in the atmosphere. In connection with this, every launch requires a new launch vehicle, which explains the high cost of putting a useful load into space -- about $2,000 per kilogram. This figure includes the expense of creating the material part of the RN, the cost of the rocket fuel, and the cost of maintaining the RN in launch position.

Scientists and engineers are now studying the possibility of using reusable RN's which would mean a substantial reduction in the cost of putting a useful load into orbit. After each stage had performed its function, it would make a soft landing on Earth, be taken to the launch pad again, repaired, serviced and used again. Calculations show that use of a partially reusable vehicle can reduce the cost of load delivery into orbit to $500 per kilogram, while a changeover to completely reusable RN's, constructed with utilization of the most recent achievements in engine construction, materials, design theory and other areas of space and rocket technology, will make it possible to reduce this cost to $10-$50 per kilogram. The RN's for lifting KES's and other large objects are exceptionally complicated. It can be assumed that the prospective superpowerful launch vehicles at the end of the 20th century will be single-stage, ballistic-type rockets with a propulsion system operating on liquid hydrogen and oxygen.

It will be launched vertically and will land vertically in a lake in the area of the launch site. It will then be towed to the launch pad for a maintenance inspection, repair and servicing. With a useful load weighing 250 tons, its launch weight will be 6,000 tons, with a dry mass of 350 tons. For comparison, let us point out that the launch weight of the "Vostok" launch vehicle was about 300 tons with a dry mass of 25 tons and a useful load weighing about 5 tons.

These superpowerful, high-efficiency RN's will be used to deliver all the component elements of a single KES, along with the interorbital space complexes and the necessary fuel reserves, into a low holding orbit over a period of 1 year. A flow of freight from Earth into space amounting to 500 tons per day can be provided with the help of a system of two superpowerful RN's.

Considering what has been said, the creation of KES's in near-Earth orbits is a realizable goal, the achievement of which entails no fundamental theoretical difficulties. However, considering the large volume of financial and material expenditures and the serious economic and social consequences, this is a large-scale problem, the solution of which must be realized on the basis of international collaboration. KES's promise to produce a considerable profit in the case of the development and creation of space and ground technical complexes with optimum parameters. The achievement of this requires a radical reduction in the production cost of solar elements, a sharp lowering of the cost of placing useful loads into working orbits, and the solution of the ecological problems that will appear and the safety problems in the development and operation of electric power stations in space.

Basic Difficulties in the Creation of KES's

Although the KES's themselves will give clean energy, the road to the development in space of a number of them sufficient to create an abundance of energy on Earth is blocked by both resource and ecological limitations that are related to the special features of the operation of space and rocket systems. According to the calculations of specialists, the creation of a system of KES's will make it possible to relay to Earth electricity with a useful power of 1.5 billion kW, which corresponds to the predicted estimate of the entire worldwide production of electricity in the year 2000. For a unit power rating of 10 million kW for a series-produced KES, the number of stations in operation would be 150. The total weight of the stations, composed of masses of solar batteries, aluminum structures, distribution networks, electronic instruments and other elements, will be fantastic: 5-10 million tons. The lifting of this weight and orbital transportation equipment into low orbits with the help of superpowerful RN's will require rocket fuel with a total weight on the order of 200-400 million tons. The weights of the required semiconducting materials and rocket fuel components exceed their predicted worldwide production by several orders of magnitude. We should also take into consideration the large volume of initial energy expenditures related to the production of the semiconducting materials for the solar batteries, aluminum for the load-carrying structures, electronic instruments, liquid hydrogen and so on. The replacement of the electricity consumed in the production and lifting of a single KES will require operation of the KES for two years.

The lifting of KES elements from Earth into low orbits with the help of highly economical and superpowerful RN's will be accompanied by contamination of the atmosphere with the hot products of the burning of the rocket fuel. Considering the imperfection of the technological processes for producing the fuel and the elements of the KES structure (semiconducting photoconverters, load-carrying elements, instruments) on Earth, in connection with this we should expect significant thermal discharges into the atmosphere (up to 10^{15} kcal during the production and lifting of only a single KES). This is fraught with serious ecological disturbances and a change in the established equilibrium of the global atmospheric processes. Thus, the resource and ecological limitations are extremely serious problems blocking the path to the diversion of worldwide power engineering into a new channel.

A Way Out: The Development of Space Production

One of the possible ways of overcoming these difficulties is to use lunar and asteroid materials to construct KES's. According to the estimates of specialists, 90 percent of a KES can be built from lunar and other extraterrestrial materials. In this case there is no need to lift large useful cargoes from Earth and, consequently, to produce a large amount of rocket fuel, so that the problem of atmospheric contamination by its combustion products is reduced. However, in space we must create efficient systems for extracting, processing and transporting the raw materials, along with the necessary production and assembly complexes. This means, in turn, the creation of orbital stations with large crews and lunar bases and stations and, consequently, the lifting of large amounts of useful cargo from Earth. Unfortunately, calculations show that even if the KES's are built from extraterrestrial materials, the raw material and ecological limitations remain in force to a considerable extent.

There exists a fundamentally different method of overcoming the main limitation standing in the path of the extensive development of space power systems. The essence of this method is that the KES's be built not near the Earth, but in areas near the Sun where there is a higher level of solar radiation; that is, that the KES's be brought close to the star, at the distance of Mercury's orbit or even closer. It is a well known fact that although the power of the flow of the Sun's radiant energy striking a single square meter on the Earth's surface that is perpendicular to the rays (the solar constant) is 1.4 kW/m^2, at a distance of 0.1 astronomical units from the Sun it is 140 kW/m^2. This means that if a KES is placed in a circular orbit around the Sun having a radius of 15 million kilometers, its solar batteries will be two orders of magnitude smaller than for a power station with the same capacity in a geostationary orbit. There will be a corresponding decrease in the weight characteristics of the KES's energy equipment.

The delivery of a KES to a near-Sun orbit can be accomplished by self-injection on the heliocentric section of a flight, using electrojet engines powered by the station's solar power plant. The transmission of energy from the KES to ground or orbital receiving units can be accomplished with the help of a laser beam. Achievements in the development of superpowerful, continuous-action laser generators make it possible to count on the future creation of systems for the transmission and reception of energy at astronomical distances. If we assume that in the future the half-angle of a laser beam can be reduced to values on the order of 10^{-9} radians by special focusing equipment, the dimensions of the transmitting and receiving systems will not reach large values. We should also allow for the fact that the aiming and control of a laser beam at astronomical distances represents exceptional difficulties, although they are all basically of a technical nature. The organization of the maintenance and repair of a KES far from Earth, the provision of an energy supply around the clock, and many other questions are also problematical. However, the reduction of a KES's necessary weight by two orders of magnitude is such a great step forward that it can cause a substantial acceleration in the use of space electric power stations in worldwide power engineering.

Another proposal that has aroused interest is the idea of removing the receiving units from the Earth's surface into the stratosphere, which will make it possible to realize the efficient transmission of energy in the millimeter and submillimeter wave bands. In connection with this there will be a sharp reduction in the size of

the transmitting and receiving antennas and a substantial reduction in the cost of creating the energy transmission and receiving system. It has been proposed that the receiving antenna be lifted with the help of aerostatic devices (dirigibles) that have a large cargo capacity and are controlled automatically.

The development of KES's is an extremely complicated problem involving various scientific disciplines: cosmonautics, rocket building, power engineering, electronics, electrical engineering, the science of materials, economics, ecology. At the present time, all these branches are in a stage of rapid development. There is no doubt that the scientists and engineers will find effective ways of overcoming the difficulties blocking the path of the creation of space power engineering complexes.

The analysis of the planned characteristics of KES's of different types, with due consideration for the achievements of developing science and technology, requires the conduct of large-scale investigations and a search for new and nonstandard solutions. This fascinating and gratifying work will lie on the shoulders of those who today are sitting behind their school desks and mastering the initial wisdom of science and who will be inspired to do this difficult and painstaking work by the grand goal of achieving an abundance of material blessings for all the people on this planet.

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USING SPACE PHOTOGRAPHY FOR AGRICULTURAL SURVEYS

Moscow SOVETSKAYA ROSSIYA in Russian 12 Mar 81 p 2

/Interview with USSR Pilot-Cosmonaut Vladimir Vasil'yevich Kovalenok, hero of the Soviet Union, Valeriy L'vovich Andronikov, director, Group on Aerospace Methods of Studying Soils, Soil Institute imeni V.V. Dokuchayev, All-Union Academy of Agricultural Sciences imeni V.I. Lenin, and E.M. Trakhov, director, Agrospace Center, Krasnodar, by V. Mal'shakov: "An Experimental Field From Orbit"; date and place not given/

/Text/ In Krasnodar, the Center for Agrospace Research (TsAKI) of the USSR Ministry of Agriculture (MSKh) has been set up at the All-Union Scientific Research, Planning and Technological Institute of Cybernetics. Its function will be to use aerospace information in the interests of agriculture. That is the subject of this interview.

/Question/ Vladimir Vasil'yevich and Valeriy L'vovich, you frequently travel to the Kuban' to work on the Agrospace Center's program. To what extent can data supplied by space science and the satellite service be used to improve the efficiency of agricultural production practices?

V. Kovalenok: Space yields much for various branches of the national economy, including agriculture. This is complicated work. The questions that can be answered from space in the interest of agriculture are acute, disturbing and extremely necessary. They include crop yield prediction, determining the degree of ripeness of different kinds of grain over large areas of the Soviet Union, and discovering plant disease in its early stages. It is very important for agricultural workers to know all of this.

Cooperative work with coworkers at the Krasnodar Agrospace Center enriches all of us mutually. And if we again have the chance to work in orbit, we will be able to approach the solution of various problems more intelligently by possessing that knowledge that is given us, in particular, by the Krasnodar Agrospace Center. At the same time, we will share with them what we see from space.

/Question/ It is probably not easy to "read" photographs and extract useful information from them.

V. Kovalenok: The objects of our observations are extremely variable. For example, the spectra of wheat in the milky-wax and mature stages of ripeness differ from

each other considerably. But the wind blows, the clouds give shade, and the pattern is already different as the ears of wheat change their reflection spectrum. The workers at the Krasnodar Agrospace Center are teaching us the skills to interpret space information correctly. If we know what crop has been planted in a field and if we know its characteristic features at different stages, then it is easier for us to understand what is happening to it. In the "Salyut-6" orbital station there is some very "smart" equipment that is improved from flight to flight. With its help we obtain large- and small-scale photographs and other information needed by the national economy.

V. Andronikov: It was discovered that the problem of investigating nature from orbit could not be solved in a flash. Thoughtful, serious work is necessary. It was no accident that the Krasnodar Aerospace Center was set up on the Kuban' River, where the natural climatic conditions make it possible to grow most of the crops cultivated in the USSR quite effectively. Here, more than 75 percent of all the agricultural land is fruitful black earth.

E. Trakhov: For the selection of the test areas and farms we followed the recommendations of the Krasnodar Scientific Research Institute of Agriculture imeni P.P. Luk'yanenko, the kray Plant Protection Station and the wishes of the Kuban'giprozem Institute. The test farms that were chosen are close to plant protection stations and agrochemical and meteorological stations and have landing fields for agricultural aviation. Our center monitors all of the agricultural areas in Krasnodarskiy and Stavropol'skiy Krays, Rostovskaya Oblast', Azerbaijan and Kalmykia. The five test regions were selected with due consideration for their natural conditions and the special features of their agricultural production.

V. Kovalenok: We have been at the experimental fields and on the experimental ranges that were specially selected for these purposes. We flew over them. We met with specialists in order to be able to cover the "bookcase" from bottom to top -- from the fields to spaceflight.

/Question/ Valeriy L'vovich, let's turn to the problem of interpreting space information.

V. Andronikov: The scientists need to have a certain "bank of portraits" of the spectral features of all the states of agricultural crops and soils. These states (standards) must be rigidly tied in with certain technical surveying conditions and certain natural data. The effect of these conditions must also be extrapolated into the future for analogous weather conditions. Let me explain: spring, for example, can be either dry or wet. Consequently, the rules for an image must correspond to the specific weather conditions.

The standards need to be assembled and, moreover, we need to use all the rich experience we have amassed from terrestrial investigations. These data will then be entered in the memory of an electronic computer that will analyze the aerospace materials and will, flawlessly and on an operational basis, separate what the specialists need.

V. Kovalenok: Remote sensing methods (from airplanes, manned stations and satellites) make it possible to study Earth from a distance. On a nationwide scale, they make it possible to organize more efficient control over the production

processes in agriculture. The Agrospace Center will collect information on climatic conditions, the pattern of emergence of areas in this region from under the snow cover, the breakup of river ice, the thawing of soil, and soil temperature. Preparations are already being made to observe from space the course of soil preparation for sowing, the development of young growth in planted crops, their ripening and harvesting, and so on. This information will be accessible for observation and subsequent evaluation. As Valeriy L'vovich has already said, it will be entered in a computer for machine processing. On the basis of incoming information it will be possible, on an operational time scale, to find optimum planning variants, make needed corrections, eliminate any disproportions that arise, and regulate the material and technical supply process.

/Question/ Where will this data bank be stored and where will the computer be located?

V. Andronikov: I think there can be a two-level system for these data. One bank, the only central one in the country, will be in Moscow. However, there must also be regional centers. One of them is the Krasnodar Agrospace Center. All the data on winter crops, sunflowers, rice and sugar beets will be concentrated on the Kuban'. For soybeans, let us say, the center will be in the Far East; for vegetable crops and green forage it will be most convenient to have the center in the central belt of Russia.

V. Kovalenok: It is possible to create improved equipment and complex automatic units, but it is necessary to study their operation. The data bank is also needed for this purpose, so that the equipment we send into space and what is working on agricultural crops here on Earth can understand what is happening where. In order to do this we are walking the fields, taking pictures, and finding the causes of crop disease or, on the contrary, learning the conditions that result in a good harvest.

/Question/ Last year the workers at the institute took part in a review of the state of the winter crops and produced operational information obtained by remote methods from AN-2 airplanes and KA-26 helicopters. This made it possible to determine the measures needed for care after sowing for each field.

V. Kovalenok: There you have a good example of how the union of sky and ground is already serving the laborers in agriculture along the Kuban'. There are hopes that in the future this union will become even stronger.

/Question/ It is very important to have an operational prediction of the grain crop yield. Using statistical data and photographs taken in space, a prediction on the crop yield of spring wheat in this country -- 91.4 million tons -- was made about a month before the beginning of the harvest. The prediction's accuracy was 2 percent.

E. Trakhov: According to the specialists' estimates, the expected economic effect from the introduction of this system for an area of 100 million hectares will be somewhat more than 300 million rubles per year, while for the country as a whole it would be about 1.5 billion rubles.

/Question/ We often hear about the investigation of the Earth's resources from space with the help of multizonal surveying. Please explain what multizonal surveying is.

V. Kovalenok: The MKF-6M photographic complex, developed by specialists in the USSR and the GDR and manufactured at the Karl Zeiss-Jena people's enterprise, is now widely used in Soviet manned spacecraft. The camera operates in six bands of the spectrum at the same time. Analysis of the six photographs makes it possible to form a more detailed and thorough opinion about those objects we are photographing: agricultural crops or soils. Synthesis of the photographs makes it possible to see, in color, the smallest changes that take place in crops because of lodging, disease and wet conditions.

With multizonal surveying it is possible to see finer differences in agricultural objects that are being investigated. There are automated electronic systems that make it possible to differentiate from 32 to 250 tones in a photograph. The pattern, image structure and image tonality are also classified. Multizonal brightness is an important interpretation feature. The scientists began to use it only recently. It can be used for the automatic interpretation of both space and aerial photographs. Right now preparations are being made so that in the future it will be possible to change over completely to machine interpretation of photographs of agricultural and other objects.

/Question/ The "Basic Directions for the Economic and Social Development of the USSR From 1981 to 1985 and the Period Until 1990" provide for the further study and mastering of space for the benefit of the development of science, technology and the national economy. Has the training of specialists in agriculture for a flight into space been proposed?

V. Kovalenkov: In time, I think, there will also be specialists in agriculture in space -- so-called space agronomists. For the time being, cosmonauts will fill this role.

11746
CSO: 1866/83

UDC 553.982:629.195

SPACE METHODS IN A SYSTEM FOR THE GEOLOGICAL STUDY OF OIL AND GAS BEARING REGIONS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 1, Jan 81 pp 3-6

BRYUKHANOV, V. N., "Aerogeologiya" All-Union Scientific Production Association

[Abstract] The optimistic tenor of literature dealing with applications of photographs taken from space to the determination of oil and gas bearing strata is justified, since the data cannot always be obtained by conventional geological or geophysical techniques. Space surveys, however, are to be incorporated as a component of the overall study of oil and gas bearing regions. This general and cursory review points out the advantages of large and small scale mapping of potential petroleum deposits from space based on the interpretation of the tectonic lineaments, fractures, faults and various other megastructures. A difficult point in geological and tectonic mapping using space materials is the interpretation of ring structures of 100 km and more as applied to the delineation of oil and gas bearing regions. One of the most complex and yet important problems in the study of potential oil fields is the determination of the areas which are the most promising for prospecting, since deep structures do not always correlate with surface photographic anomalies or known local structures. While it is still difficult to estimate the economic impact of space geological techniques on the petroleum extraction industry, the widescale use of space imaging of geological structures in oil and gas bearing regions will substantially boost the efficiency of prospecting work and accelerate the exploitation of new areas. References 10: 7 Russian; 3 Western.
[57-8225]

UDC 553.982:550.814

MAJOR QUESTIONS IN THE APPLICATION OF AERIAL AND SPACE PHOTOGRAPHIC MATERIALS TO OIL AND GAS PROSPECTING

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 1, Jan 81 pp 48-55

ROMASHOV, A. A. and GALAKTIONOV, A. B., "Aerogeologiya" All-Union Scientific Production Association

[Abstract] Oil and gas prospecting studies based on aerial and space photography can be broken down into three kinds: 1. Large scale surveys (using primarily maps with scales of from 1:5,000,000 to 1:2,500,000), which taken in large areas and include the comparative study of regions; 2. Regional surveys (with maps having scales of from 1:1,000,000 to 1:200,000, primarily in regions with proven oil and gas bearing deposits), and 3. Detailed surveys (aerial photography producing group structural and geological maps with scales of 1:100,000 to 1:50,000), to specify the structure of known and ascertain new deposits. The stages in these three types of studies are subdivided as follows: Preliminary laboratory studies, field observations and analysis following the field work. This paper is a general discussion of a flow chart showing the overall organization of all such oil and gas prospecting operations. An example of the implementation of the proposed organizational scheme is the "Space Photographic Tectonic Map of the Aral-Caspian Region" with a scale of 1:2,500,000, compiled by the staff of the "Aerogeologiya" All-Union Scientific Production Association in conjunction with the specialists of the Institute of Geology and Development of Mineral Fuels. Other maps are noted: a structural tectonics schematic for the southeastern portion of the Caspian depression basin with a scale of 1:1,000,000, including the oil and gas bearing ground of the Yuzhno-Emba oilfields and a map compiled from the structural interpretation of space photos combined with geological and geophysical data on a scale of 1:50,000 for the territory of the Buzachinsk petroleum bearing regions. Though none of these maps is reproduced, it is noted that the use of aerospace data in oil and gas prospecting is quite efficient at the scientific, procedural and economic planning levels. Figures 1; references: 14 Russian.
[57-8225]

UDC 550.814:553.982(47-12)

EXPERIENCE WITH THE COMPILATION OF GEOLOGICAL MAPS FROM SPACE PHOTOGRAPHS FOR CLOSED OIL AND GAS BEARING REGIONS (USING THE EXAMPLE OF THE DEPRESSION BASIN NEAR THE CASPIAN SEA)

Moscow IZVESTIYA VYSSKIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 1, Jan 81 pp 56-59

VOLCHEGURSKIY, L. F. and PRONIN, V. G., "Aerogeologiya" All-Union Scientific Production Association

[Abstract] The features of the geological structure of the depression basin bordering the Caspian Sea are shown in detail with a map compiled from space photographs. The map is used as an illustration of the efficacy of space imaging techniques and the subsequent geological interpretation (the scale is 1:1,000,000); the following features are indicated: areas of the predominant development of fold dislocations (brachyform, diapiric, brachyform-diapiric, fully linear and sublinear intermittent dislocations), the contours showing the stratigraphic lithology of the region, fault lines, ring structures as well as the boundaries of the predominant development of Quaternary deposits and the correspondence between surface features and elements of the deep structure. The abbreviations used in such maps are also explained (i.e., if a structure is found in either a sedimentary cover, a crystalline basement or at a Mohorovic surface, the letters O, F or M are used respectively, with the method of determination indicated in parentheses). Geological maps derived from space photography contain comprehensive geological information on a region, since geophysical mapping data are used in its compilation, and such maps can thus be treated as the basis for drawing up maps forecasting closed oil and gas bearing regions. Figures 1; references: 5 Russian.
[57-8225]

UDC 551.24:629.195(47+57)

FAULTS AND RING STRUCTURES IN THE SOUTHERN USSR BASED ON OBSERVATIONS FROM THE 'SALYUT-6' ORBITAL SCIENTIFIC STATION

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 1, Jan 81 pp 7-12

KOZLOV, V. V., KOVALENOK, V. V. and IVANCHENKOV, A. S., "Aerogeologiya" All-Union Scientific Production Association

[Abstract] An experiment was performed between June and November of 1978 to observe geological structures in the southern portion of the USSR from the "Salyut-6." The cosmonauts were trained to objectively observe faults and lineaments without attempting to prove any geotectonic hypothesis. Some 71 faults and lineaments ranging from 65 to 1,500 km were observed with the bulk of these falling between 150 and 250 km. The large faults (the main Karatauskiy,

Dzhalair-Naymanskiy, Ayaguzsko-Urdzharskiy and the Primorskiy) could be seen quite clearly from orbit. The tectonic lines observed from space can be broken down into five groups relative to the known faults: 1. Lines which completely coincide with faults known from geological date (25.4%); 2. Lines which match in individual sections with known faults (25.2%); 3. Lines which coincide directionally with faults at a depth established by geophysical data (12.7%); 4. Lines corresponding to faults and lineaments which were additionally interpreted in space photographs (9.9%); 5. Conjectured lines of a fault nature which were visually observed from space, but which need further study (29.5%). A general map of the faults and ring structures is sketched for the southern USSR and histograms are plotted showing the distribution of the faults and lineaments with respect to length and direction; a similar histogram is drawn for oval and ring structures as a function of their average diameters. Figures 6.
[57-8225]

UDC 550.24(202)(47-12)

UTILIZATION OF SPACE MATERIALS IN ESTABLISHING THE TECTONIC REGIONS OF THE SOUTHEAST PORTION OF THE EASTERN EUROPEAN PLATFORM

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA A RAZVEDKA in Russian No 1, Jan 81 pp 18-23

VOLCHEGURSKIY, L. F. and PRONIN, V. G., "Aerogeologiya" All-Union Scientific Production Association

[Abstract] The deep structures in the southeastern region of the Eastern Europe n platform are masked to a considerable extent by friable surface neogene-quaternary deposits. The sparse grid of regional seismic profiles usually does not allow for an unambiguous determination of fracture and fault structures. However, space photographs of the area can be interpreted to ascertain large geostructural units, regional faults, extended plicated structures and small disjunctive formations. Space imaging reveals several large tectonic blocks with an area of up to 10^4 km^2; the boundaries of these blocke are clearly marked by extended lineaments which are equated with deep faults or are interpreted as regions of increased fissuring. The general area, which includes the depression basin near the Caspian Sea, is broken down into seven major tectonic regions and the geological features of these regions and their boundaries are discussed: El'tonskiy, Inderskiy, Uil'skiy, Kokpektinskiy, Astrakhanskiy, Gur'yevskiy and the Yuzhnoembensko-Buzachinskiy bocks. The considerable information content of space photographs makes it possible to target specific regions for detailed studies to improve the efficacy of petroleum prospecting. Figures 1; references: 5 Russian.
[57-8225]

UDC 528.77:551.4(574.3)

QUESTIONS OF LANDSCAPE FEATURE INTERPRETATION OF PHOTOGRAPHS TAKEN FROM SPACE (USING THE EXAMPLE OF THE TURAN PLATFORM)

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 1, Jan 81 pp 24-30

LION, Yu. A. and SOLOV'YEVA, L. I., "Aerogeologiya" All-Union Scientific Production Association

[Abstract] Geologically interpreting photographs of closed regions taken from space requires that clear relationships be established between the image, the landscape and the geological structures. While remote imaging from space for geological test areas has provided considerable data on the amount of geological information in such imaging, attention must be concentrated on the morphological features of the areas and linear objects which are photographed to best resolve the issue of relating images and structures. The results of previous structural, geomorphological and hydrogeological studies of the Turan platform has demonstrated the tectogenic nature of its relief and its genetic relationship to the geologic structure. Appearances of very new local tectonic structures (uplifts) have been extensively studied in oil and gas prospecting surveys. This produces the objective prerequisites for reliable geological structural interpretation of data from space photographs of such arid plains. The block tectonics of the Mynsualmas region revealed by landscape and geomorphological interpretation of data from the "Meteor" and "Salyut" satellites are compared with previous structural information from ground surveys. The interpretation results are in good agreement both in the overall features and in the details with the concepts of the tectonic structure of the territory and are reflected in the structural maps for the various stratigraphic levels, and especially in the maps of the surface relief of the consolidated basement. The major lineament areas correspond to deep faults (for example, the northern Ustyurt fault) or flexure regions (the Shorshikudukskaya and Samskaya areas). A structural denudation map is drawn of the Ustyurt plateau plain showing the geological interpretations of the landscape-geomorphological analysis of intermediate scale space photographs of the test reference section of the Mynsualmas region. The final interpretational data reveals local structures and makes it possible to move on from the search for random geomorphological or landscape anomalies to the systematic study of geomorphological features. Figures 2; references: 9 Russian.
[57-8225]

UDC 550.814(202):553.499

PREDICTING MERCURY ORE DEPOSITS BASED ON THE COMPREHENSIVE ANALYSIS OF THE RESULTS OF THE INTERPRETATION OF SPACE PHOTOGRAPHS AND GEOCHEMICAL DATA (BASED ON THE EXAMPLE OF THE KHAYDARKAN ORE FIELD)

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 1, Jan 81 pp 60-66

YABLONSKAYA, N. A. and MELESHKO, A. I. "Aerogeologiya" All-Union Scientific Production Association, Institute of Mineralogy, Geochemistry and Crystallochemistry of the Rare Elements of the USSR Academy of Sciences

[Abstract] The Khaydarkan ore field is located in the central region of the fold belt of the southern Tien-Shan mountain range. The ore bodies are localized in uplift blocks and anticlinal folds of a high order. The determination of the location of these ore bodies through the correlation of geochemical ground data and satellite photography is treated in considerable detail. Maps are drawn showing the geological structures governing the placement of useful minerals on the eastern flank of the Khaydarkan ore field, the contemporary structural tectonics of this field and a schematic indicating the distribution of mercury on the eastern flank with lines plotted for Hg concentrations of less than 0.2, 0.2 - 1 and more than 1 g/ton. An analysis of geological and geochemical data based on antimony-mercury mineralization criteria and other factors shows that the areas of the eastern and southeastern flanks of the Khaydarkan field have promising areas which have been studied in insufficient detail; the most promising sector is the northern region of a cupola-like uplift; two other promising are are ascertained and the efficacy of the joint utilization of geochemical data and remote imaging materials in such studies is noted. Figures 3; references: [illegible] Russian.
[illegible]

UDC 551.49(202)(407.1)

HYDROGEOLOGICAL RESULTS OF THE APPLICATION OF SPACE TECHNIQUES TO THE STUDY OF THE NORTHERN EUROPEAN REGION OF THE USSR

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian [illegible]

[illegible], V. I., [illegible], V. A. and SMIRNOV, V. M., "Aerogeologiya" All-Union Scientific Production Association

[Abstract] To study fault lines based on materials from a number of organizations, a map was compiled showing sources exhibiting an increased concentration of salts, which were then compared with a map of fault lines. The anomalous sources and their gradations were ascertained based on the chlorine ion concentration. Sources were considered to be anomalous when the chlorine content in the underground

waters was greater than 50 mg/l. These geochemical anomalies (including some sources of salty water of an unknown composition, sources of spontaneous gas liberation, hydrogen sulfide and warm or hot water) are then correlated with basement faults detected throughout the interpretation of photographs taken from space. A map is provided showing the faults and the locations of the anomalies over a large area of the northwestern USSR. The laws governing the distribution of anomalous sources along large rivers were determined as well as basement faults which were manifest in the sedimentary cover as regions of increased fissuring. The use of space materials was particularly effective in the latter case, since the study of fractures by conventional geological methods in the closed and poorly exposed northern European area of the USSR is difficult. The regularity of the distribution of anomalous sources which was revealed not only confirmed the reliability of fault detection, but in the future will assist in correcting them in the interpretation of space photographs. Figures 1; references: 8 Russian.
[57-8223]

UDC 551.593.13

STRATIFIED STRUCTURE OF THE TEMPERATURE FIELD IN THE ATMOSPHERE, ACCORDING TO REFRACTION MEASUREMENTS MADE FROM THE 'SALYUT-6' ORBITAL STATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 17, No 2, Feb 81 pp 115-122 manuscript received 8 Apr 80

GRECHKO, G. M., GURVICH, A. S., ROMANENKO, Yu. V., SOKOLOVSKIY, S. V. and TATARSKAYA, M. S., Institute of Physics of the Atmosphere, USSR Academy of Sciences

[Abstract] The first crew of the "Salyut-6" orbital station took photographs of the Sun when it was low above the horizon so that the refraction of its rays in the atmosphere could be studied (assuming a spherically symmetrical atmosphere). A sextant was used to measure the Sun's visible angular vertical size, with the time when it reached a certain value being noted; 44 such measurements were made. The Sun was also photographed, with the time also being noted; 26 photographs were taken of the Sun at different heights above the horizon. The authors present the mathematical apparatus that was used and conclude that measurements of the Sun's oblateness (due to refraction) can be used as a source of information about the vertical profile of air density. Figures 6; references 10: 8 Russian, 2 Western.
[84-11746]

UDC 551.32:629.78

DEVELOPMENT OF AND PROSPECTS FOR SPACE GLACIOLOGY

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 7-15
manuscript received 22 Jul 80

KOTLYAKOV, V. M., Geography Institute, USSR Academy of Sciences, Moscow

[Abstract] Because of the scale of the phenomena involved, space photography is vital for the solution of the following problems in glaciology: 1) investigating the snow and ice covers of the Earth's land and ocean areas, respectively, and their temporal variability; 2) investigating the formation and variability of snow and ice phenomena in mountainous areas; 3) observing the snow and ice regimes in specific areas. The author lists the scale of the photographs needed for the solution of each of these problems and points out that such studies are also of great benefit to climatology and hydrology. In order to implement this program, in recent years all cosmonauts have been given brief courses in glaciology, with some practical training featuring TU-134 flights in the Pamir Mountains. A subject of primary concern is the so-called "pulsating" glaciers, which can move suddenly and rapidly and cause destructive slides of water, ice and stone and which have features that can be studied quite easily from space. The author describes some of the practical achievements of space glaciology and discusses the organization of a service to collate and utilize the masses of data now becoming available. Figures 2; references 13.
[65-11746]

UDC 550.814:629.78(575.1)

COMPARISON OF THE GEOLOGICAL INFORMATION CONTENT OF MATERIALS OBTAINED BY REMOTE SURVEYING METHODS, USING THE SOUTHERN TYAN'-SHAN' MOUNTAINS AS AN EXAMPLE

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 27-30
manuscript received 18 Jul 80

GLUKH, A. K., Experimental Methodological Expedition, Uzbek SSR Ministry of Geology, Tashkent

[Abstract] The Southern and Northern Nuratau ranges in the southern Tyan'-Shan' Mountains have been studied in considerable detail by terrestrial geological and geophysical methods and are a suitable subject for a comparative evaluation of the information content of materials obtained by aerospace methods. The following materials were used in the evaluation: small-scale (1:140,000) high-altitude aerial photographs; radar photos with a scale of 1:90,000; space photos with regional and detailed levels of generalization; aeromagnetic surveying magnetic field maps with a scale of 1:25,000; gravimetric surveying maps with a scale of 1:200,000, geological maps with scales of 1:1,000,000 and 1:200,000. Various objective criteria were used to evaluate the different types of materials.

The author lists the advantages and shortcoming of each type and concludes that the use of aerial and space photographs to solve problems of tectonic zoning and geological mapping can be recommended. References 2.
[65-11746]

UDC 528.72(202):535.36

FORMATION OF AN OPTICAL IMAGE WHILE ALLOWING FOR LATERAL ILLUMINATION

Moscow ISSLEDOVANIYA ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 48-57
manuscript received 9 Jun 80

MISHIN, I. V. and TISHCHENKO, A. P., State Scientific Research Center for the Study of Natural Resources, Moscow

[Abstract] Since intrusive lateral illumination from surface sections with different degrees of reflectivity complicates photographic surveying of the Earth from space, the authors attempt to find the size of an area of underlying surface, the reflection from which determines lateral illumination in order to obtain an approximate estimate of the contribution of lateral illumination to the light intensity of an element of an optical image as a function of the scanner's viewing angle, and construct a procedure for compensating for amplitudinal distortions in the restoration algorithm of the two-dimensional distribution of the brightness of a light field, as recorded by a satellite. They conclude that the light intensity of an image element depends only on surface albedo variations in a certain area and that lateral illumination increases as the optical thickness of the medium between the satellite and Earth does and as the scanner's viewing angle decreases, and propose a simple algorithm for compensating for amplitudinal distortions that involves the computation of a two-dimansional integral of the convolution of a scattering function with a variable image brightness component. Figures 4; references 13.
[65-11746]

UDC 551.467:629.78

RADIOTHERMAL EMISSIONS OF SNOW CAPS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 58-62
manuscript received 13 May 80

GERSHENZON, V. Ye., KHAPIN, Yu. B. and ETKIN, V. S., Institute of Space Research, USSR Academy of Sciences, Moscow

[Abstract] The authors discuss the results of an experimental investigation of the radiobrightness temperature spectra of snow caps in the 1.7-89 GHz band, based on aerial measurements. The superhigh-frequency radiometer complex used had radiometers set at frequencies of 1.7, 3.6, 7.5, 9, 20 and 89.37 GHz and

was installed in an IL-14 laboratory airplane. After a discussion of the results, the authors conclude that the short millimeter band can be used (in combination with some long-wave band in order to differentiate between land and water) to detect and determine the internal structure of a snow cap's upper layers, while the long millimeter and short centimeter bands can be used to evaluate the thickness of a snow cap, it being the case that the deeper the snow, the longer the waves that are needed. Figures 5; references 11: 4 Russian, 7 Western.
[65-11746]

UDC 528.72(202):535.36

IMAGE TRANSFER THROUGH A TURBULENT LAYER, USING MODEL MEDIA

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 71-73
manuscript received 11 Feb 80

BAYBULATOV, F. Kh., DEMLER, A. I., MININ, V. F. and TALANIN, A. M., Central Scientific Research Institute of Scientific and Technical Information and Technical and Economic Research, Moscow

[Abstract] The authors present the results of experimental studies of the optical transfer function of a thin turbulent layer, allowing for its position and scattering indicatrix, that was modeled with glass plates etched by hydrofluoric acid. Studies of the plates showed that with sufficient averaging, near a zero scattering angle their indicatrices are described quite well by a Gaussian function, as is the case for a turbulent atmosphere. The results of the experiments showed that: for full-scale measurements, a relationship derived theoretically describes the optical transfer function of a thin turbulent layer quite well and allows for its position and the optical system's resolution; the quality of viewing through such a layer deteriorates monotonically as the characteristic angle of the turbulent layer's scattering indicatrix, the receiving optics' resolution and the distance between the layer and the object being observed increase. Figures 1; references 4.
[65-11746]

UDC 525.629.7

CLOUD COVER IN PLANNING SPACE SURVEYS OF THE EARTH, ACCORDING TO THE RESULTS OBTAINED DURING THE FLIGHT OF THE 'SOYUZ-22' SPACECRAFT

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 78-82
manuscript received 25 Apr 80

GORBUSHINA, E. A. and KOTTSOV, V. A., Institute of Space Research, USSR Academy of Sciences, Moscow

[Abstract] Extensive areal surveying requires both long-term and operational planning. The former involves the use of a statistical model of cloud cover, which has been facilitated by photographs taken by the ESSA meteorological

satellite. The latter necessitates determining the current cloud cover over the area to be surveyed so as to make the best use of time and equipment. The "Soyuz-22" was launched in September, with part of its mission being a detailed survey of the USSR. An operational planning group at the Flight Control Center, using a computer, determined when to take pictures. Although the proper use of long-term and operational planning is still in its early stages, the authors feel that it will soon reach a level where unmanned spacecraft can be used for surveying. References 2: 1 Russian, 1 Western.
[65-11746]

UDC 535.243.3:629.78

MATHEMATICAL MODELS OF CLOUD COVER FOR A PRIORI PLANNING OF OBSERVATIONS OF THE EARTH FROM SPACE

Moscow ISSLEDOVANIYA ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 83-89 manuscript received 3 Jul 80

BOBRONNIKOV, V. T.

[Abstract] Since cloud cover makes Earth observations from space more difficult in the optical and infrared bands, the development of methods to allow for its effect is now an urgent problem. The author's approach to this problem is based on the approximation of temporal and spatial changes in the amount of cloud cover over regions being observed by discrete Markov random processes, which makes it possible to obtain quite compact models that allow for the non-Gaussian nature of the processes for arbitrary intervals between observations and distances between observed regions. After developing the theoretical basis, the author gives an example of the development of spatiotemporal Markov cloud cover models and shows how they can be used to solve various problems related to Earth observations from space where cloud cover is involved. References 11: 9 Russian, 2 Western.
[65-11746]

UDC 550.3:629.78

RESEARCH AND DEVELOPMENT IN ECONOMICAL METHODS FOR CONDUCTING GEOPHYSICAL EXPERIMENTS

Moscow ISSLEDOVANIYA ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 90-95 manuscript received 26 May 80

BELYAYEV, M. Yu. and TYAN, T. N.

[Abstract] The authors discuss problems related to determining the position of a spacecraft relative to its center of mass on the basis of telemetric measurements by orientation sensors when passive methods are used to control the spacecraft's angular motion, as well as problems involved in correlating scientific

measurements, and also analyze the use of this approach to control the "Salyut-6" station during the conduct of several geophysical experiments. They conclude that: 1) the use of gravitational stabilization and torsion makes it possible to expand the geophysical research program on stations of the "Salyut" type; 2) the orientation determination and navigational correlation algorithms and programs that they have developed increase the effectiveness of the analysis of the results of geophysical experiments; 3) investigations of gravitational stabilization and torsion modes carried out according to the data on their orientation monitoring system indicate the feasibility of using them in analogous programs for investigating the Earth from space. Figures 2; references 4.
[65-11746]

UDC 528.74

OPTIMUM PROJECTION OF SCANNER PHOTOGRAPHS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 96-99
manuscript received 31 Jul 80

KNIZHNICHENKO, V. I.

[Abstract] In order to be of any practical use, space photographs must be converted into some cartographic projection that is optimum from the viewpoint of intrinsic distortions. The use of digital computer technology is very promising in this respect. The author attempts to derive conformal projection expressions that are free from certain flaws present in the methods now used. He concludes that this is not difficult if the relationships between the spherical coordinates and the number of lines and columns in a photograph is determined. Figures 2; references 4: 2 Russian, 2 Western.
[65-11746]

UDC 528.72:518

OPTIMUM LINEAR PREDICTION FOR THE GEOMETRIC CORRECTION OF SPACE PHOTOGRAPHS OF THE EARTH AND OTHER PLANETS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 100-104
manuscript received 6 Jun 80

PERMITINA, L. I. and LEBEDEV, S. V., Geography Department, Moscow State University imeni M. V. Lomonosov, and Moscow Institute of Engineers of Geodesy, Aerial Surveying and Cartography

[Abstract] The authors investigate the possibility of using the method of optimum linear prediction for the geometric correction of small-scale space photographs of the Earth and other planets in order to avoid the use of polynomial transformations involving polynomials of higher powers. The method is based on the

use of covariance relationships that reflect the connection between physical phenomena being investigated, which in this case is the relationship between the geometric distortions in space photographs and the distances between points on the photographs. The authors derive a technique for using optimum linear prediction and state that it is effective, particularly for the processing of ultra-small-scale photographs such as those obtained with geostationary satellites, since they make it possible to identify a large number of reference points on the image of the surface. Figures 1; references 13: 10 Russian, 3 Western. [65-11746]

UDC 528.72(202)

STRUCTURE OF A TERMINAL STATION FOR IMAGE PROCESSING

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 81 pp 105-107 manuscript received 11 Feb 80

NIKUL'TSEV, V. S., Computer Center, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] The author discusses some aspects of image processing and how they affect the structure of a terminal station used for that purpose. In the most general terms, he describes the different types of operations that may need to be performed, how data need to be organized, what hardware and software are required, and how the operator can work in the dialog mode and make decisions. [65-11746]

UDC 553.98:629.78

METHODOLOGICAL ASPECTS OF USING REMOTE SURVEYING MATERIALS IN OIL AND GAS PROSPECTING WORK

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 9-13 manuscript received 11 Feb 80

KOSTRYUKOV, M. I. and TSARENKO, P. T., Aerogeological Party, Main Administration for Petroleum and Gas for the Tyumen' Region, Tyumen'

[Abstract] The proper sequence for performing oil prospecting work using remote surveying methods is as follows: 1) preparation of the remote geological-geophysical materials; 2) establishment of the indicators of the investigated territory's deep structure through the use of standards; 3) zoning of this territory according to deep structure indicators that are found; 4) performance of methodological and experimental test investigations to detect photographic variations in the deep structure indicators in order to establish their optimum expressiveness; 5) performance of auxiliary types of interpretation of remote

materials (structural, structural-geomorphological, topographic-structural); b) issuing of practical recommendations for the purposeful conduct of seismic surveying work and the interpretation of the seismic data with due consideration for the results of the types of interpretation mentioned above. The authors discuss these points in further detail and mention that a special subunit has been set up in the Western Siberian Geophysical Administration to do this kind of work and go on to discuss its operations. They indicate that general-purpose stereophotogrammetric equipment is of great use in this type of work. References 8.
[113-11746]

UDC 553.042:629.78(235.222+235.223)

METALLOGENY OF AREAL MORPHOTECTONIC STRUCTURES IN THE ALTAY-SAYAN' FOLDED AREA, AS ESTABLISHED ON THE BASIS OF SPACE PHOTOGRAPHS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Spr 81 pp 18-24
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GRITSYUK, Ya. M., ROSSIKHINA, Z. S. and TURBIN, V. A., Western Siberian Territorial Geological Administration, Novokuznetsk

[Abstract] Using several hundred space photographs taken in the visible and near infrared bands of the spectrum by a "Meteor" satellite photoscanner system, the authors performed a regional structural-tectonic study of the Altay-Sayan' folded area and the regions adjacent to it. Their study showed that there are three main groups of features: arched uplifts, "resistant masses" and oval depressions. They discuss each of these features in detail, as well as the linear and arc-shaped structures that frame the arched uplifts and resistant masses. Among their conclusions, they state that it is still too soon to be able to use these materials to predict the presence of minerals, since the use of space photographs in geological work is still in its infancy and the significance of the spatial regularities has not yet been determined. Figures 1; references 9.
[113-11746]

UDC 553.7.031+551.24:629.78

RELATIONSHIP OF SUBTERRANEAN WATERS AND AFTERSHOCKS OF THE DAGESTAN EARTHQUAKE OF 14 MAY 1970 TO LINEAMENTS REVEALED BY SPACE PHOTOGRAPHS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 25-30
manuscript received 4 Nov 80

BUNIN, G. G., Geology Institute, Dagestan Branch, USSR Academy of Sciences, Makhachkala

[Abstract] Using space photographs taken by the "Soyuz-12" satellite, the author studied the part of the Dagestan wedge that, in the form of a meridional protrusion,

complicates the strike of the folded structures on the northern slope of the eastern part of the Greater Caucasus Mountains and is a region subject to severe earthquakes. A comparison of the lineaments revealed by these pictures and the more than 100 subterraneans water sources in this area shows that the locations of the latter are apparently controlled by the former. All the aftershocks of the 14 May 1970 earthquake were grouped at certain depth levels, but not where they should have been according to seismic theory. The author believes he has established a correlation between the locations of the aftershock foci and these same lineaments, but states that much additional work needs to be done on both questions. Figures 2; references 8.
[115-11746]

UDC 528.94+631.4:629.78(235)

USING SPACE MATERIALS IN THE MAPPING OF THE SOILS OF THE BAYKAL AND NORTHERN TRANS-BAYKAL AREAS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 31-35
manuscript received 11 Feb 80

KUZ'MIN, V. A., Institute of the Geography of Siberia and the Far East, Siberian Department, USSR Academy of Sciences, Irkutsk

[Abstract] The author used spectrozonal and black-and-white small- and medium-scale space photographs taken in the middle and at the end of June, plus the results of aerial surveys and ground expeditions, in an attempt to determine the utility of space photographs in soil mapping. He states that different types of photographs are more useful for different types of features and that the future use of multizonal photographs will provide even more information, although a set of interpretation standards still needs to be developed. Figures 1.
[115-11746]

UDC (551.525+551.526):629.7

DETERMINING THE TEMPERATURE OF THE EARTH'S SURFACE BY THE ANGULAR SCANNING METHOD

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 36-44
manuscript received 29 Aug 80

GORODETSKIY, A. K., Institute of Oceanography imeni P. P. Shirshov, Moscow

[Abstract] The author discusses a method of determining the temperature of different types of surfaces (land and water) on the basis of the angular path of the outgoing radiation, providing that the minimum amount of initial data consists of measurements made at three different zenith angles. He gives the initial relationships, calculates and approximates the angular path of the

radiation, allows for the surface's radiating capacity and absorption selectivity and considers sources of temperature determination errors. His conclusions are: 1) in order to extrapolate the intensity of the outgoing radiation into an air mass (the basis of separating a surface's intrinsic radiation from that of the surface-atmosphere system), three measurements of the outgoing radiation are sufficient; 2) when ground cover is present, the mean-square error in the determination of the surface's temperature is 0.5 K when the measurement error is 0.1 K and there are moderate requirements for the accuracy of the additional information on the surface's radiating capacity and the moisture content and optical thickness of the atmosphere; 3) a parallel determination of the mean-square angles of the surface's inclination is necessary for a sea surface, since it makes it possible to evaluate the con ribution of the atmosphere's reflected counterradiation. Figures 4; references 15: 8 Russian, 7 Western.
[113-11746]

UDC 631.4:629.78

SELECTING THE SPECTRAL INTERVALS OF REMOTE SENSING INSTRUMENTS IN ORDER TO DIFFERENTIATE NATURAL OBJECTS BY THEIR SPECTRAL CHARACTERISTICS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 57-62
manuscript received 16 Jul 80

BALABANOV, V. V., GOGOKHIYA, V. V. and DOBROZRAKOV, A. D., State Scientific Research Center for the Study of Natural Resources, Moscow

[Abstract] Because of the large amounts of information contained in space photographs of the Earth that are taken in multiple bands of the spectrum and the difficulties involved in transmitting and processing them, selection of the optimum spectral interval (or combination of them) is a matter of considerable importance. The authors discuss one method of doing this based on the determination of the most informative features of a natural object with respect to its brightness coefficients in different bands of the spectrum. Figures 1; references 8.
[113-11746]

UDC 502.3:528.722

EXPERIMENTAL TECHNIQUE FOR DETERMINING THE PARAMETERS OF ANTENNAS OF ON-BOARD RADIOTHERMAL COMPLEXES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 63-75 manuscript received 4 Sep 80

VESELOV, V. M., MILITSKIY, Yu. A., MIROVSKIY, V. G., SHARKOV, Ye. A. and ETKIN, V.S., Institute of Space Research, USSR Academy of Sciences, Moscow

[Abstract] Highly sensitive airplane- and satellite-borne radiothermal complexes have been built in recent years and are being used to investigate the fine characteristics of the radiothermal fields of surfaces. On the basis of work in processing the results of on-board radiothermal measurements performed from 1974 to 1979, the authors refine a previously suggested technique for absolute and relative radiothermal measurements and propose a special technique for processing radiothermal registrograms for the purpose of obtaining estimates of a series of important antenna parameters. Their refinement states that in order to conduct correct absolute and relative on-board radiothermal experiments, it is necessary to measure and regularly recheck the following antenna parameters with sufficient accuracy for practical purposes (about 10-20%): 1) width of the antenna radiation pattern main lobe; 2) value of the scattering coefficient; 3) values of the function of the surface's current y coordinate for the given model of an antenna and its structural features relative to its placement on the carrier. The authors' special experimental technique enables these parameters to be measured and checked on a regular basis, without removing the antenna and with adequate accuracy. The technique also enables the following parameters to be measured: 1) values of the averaged brightness temperatures of the signals received by the main lobe and the side radiation zone; 2) relative angular spatial location of the centers of the antenna radiation patterns in a multichannel complex. Figures 7; references 27: 18 Russian, 9 Western.
[115-11746]

UDC 528.727

INPUT-OUTPUT OF MULTIZONAL VIDEO INFORMATION WITH ELIMINATION OF INFORMATION REDUNDANCY

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 82-86 manuscript received 24 Apr 80

ASMUS, V. V., MISHKINS, A. S., RIVKIN, L. Yu., TISHCHENKO, S. P. and SHAPOVALOV, S. V., State Scientific Research Center for the Study of Natural Resources, Moscow

[Abstract] A unit for coupling a ground reception point with the computer of an experimental, specialized computer complex has been developed at GosNITsIPR. It will be used for the digital input of quadrizonal video information from

a low-resolution scanner so that this information can then be processed. The results are displayed on four black-and-white and one color photorecorder. The authors describe the equipment used in the complex and give its specifications. Information redundancy is eliminated through the use of differential pulse-coded modulation. Figures 2; references 2.
[115-11746]

UDC 528.72(202):629.78

PROSPECTS FOR AUTOMATIC ANALYSIS OF AEROSPACE PHOTOGRAPHS IN A SYSTEM FOR MONITORING ANTHROPOGENIC CHANGES IN ATMOSPHERIC AIR

Moscow ISSLEDOVANIYA ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 87-91
manuscript received 11 Feb 80

KITOV, A. D., Siberian Power Engineering Institute, Siberian Department, USSR Academy of Sciences, Irkutsk

[Abstract] In order to monitor atmospheric pollution with the help of multispectral space photographs, it is necessary to categorize pollutant sources by such parameters as: the object's brightness (or optical density), which is usually given on several spectral channels; the ratio of the object's area to its perimeter; the ratio of the number of protrusions around an object's edge to its perimeter; the ratio of the number of protrusions around an object's edge to its perimeter; length of the object (elongation of the pollutant cloud when there is wind or roundness when it is suspended in a basin); structural-physical characteristic, which corresponds to variability of brightness and size and relative position of smoke clouds as the distance from the source increases. The author discusses each of these elements in detail, as well as the possibility of automating their analysis, which is a project now being realized at the Power Engineering Institute of the Siberian Department, USSR Academy of Sciences. References 7.
[115-11746]

UDC 528.721

PHOTOGRAMMETRIC AND CARTOGRAPHIC FEATURES OF STILL SPACE PHOTOGRAPHS OF THE EARTH (ON THE EXAMPLE OF THE MKF-6 ORBITAL MULTIZONAL SURVEYING CAMERA)

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 92-96
manuscript received 30 Oct 80

NOVAKOVSKIY, B. A., Geography Department, Moscow State University imeni M. V. Lomonosov

[Abstract] From the photogrammetric and cartographic viewpoints, one of the most important features of space photographs is that the high altitude of the projection center makes the projection close to orthogonal. The author discusses

this fact in relation to the MKF-6 camera, which takes pictures in six bands of the spectrum, and analyzes its prospects for use in photogrammetry and cartography. He concludes that it has good prospects for use in thematic and specialized cartography for purposes of studying natural resources and protecting the environment. Another prospective use is the investigation of the natural texture of natural objects or formations for purposes such as the development of substantiated cartographic symbolics on general geographic and thematic maps and photographic maps. Figures 2; references 6.
[115-11746]

UDC 629.78:528.7

COMPARATIVE EFFECTIVENESS OF AIRPLANES AND SATELLITES IN INVESTIGATIONS OF THE EARTH'S NATURAL RESOURCES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 97-102
manuscript received 29 Jul 80

ZIMAN, Ya. L. and MISHEV, D. N., Institute of Space Research, USSR Academy of Sciences, Moscow, and Central Laboratory of Space Research, Bulgarian Academy of Sciences, Sofiya

[Abstract] The authors discuss two aspects of the question of whether airplanes or satellites are more effective in investigating the Earth's natural resources. The first concerns optimizing the requirements for spatial resolution of video information about the Earth's surface. The conclusion reached by several researchers is that for remote sounding, the optimum resolution is 20-30 m. The second question discussed is the technical possibility of obtaining video information from space with that level of spatial resolution. Recent advances have made it possible to create electrooptical systems with a resolution of 20-30 m and higher. Since both airplanes and satellites can be used to take photographs with the required resolution, the question is one of effectiveness of utilization. The authors' conclusion is that neither is inherently preferable, so the choice depends on the specific situation and elements that can affect it, such as meteorological factors. Figures 4; references 4.
[115-11746]

UDC 629.19:551

FORMATION AND CONTROL OF A SPACE OBSERVATION SYSTEM FOR SOLVING VARIOUS NATIONAL ECONOMIC PROBLEMS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 81 pp 103-110
manuscript received 1 Jul 80

M[illegible]RENKO, O. P. and SMOL'YANINOV, Yu. A.

[Abstract] The authors present one possible approach to the solution of the problem of forming and controlling space observation systems, which usually consist of a number of satellites carrying numerous pieces of equipment, plus all their support and information processing facilities. Using a system of geostationary satellites as an example, they develop the mathematics of system control and conclude that the area of possible controls is extremely large. In order to optimize the choice, they use the method of random search with contracting steps which makes it possible to narrow the area of possible controls considerably at each step, and formulate an algorithm for using it with a computer.
[illegible] V.
[115-1?]

SPACE POLICY AND ADMINISTRATION

SAGDEYEV ON ACHIEVEMENTS AND PROSPECTS OF SPACE TECHNOLOGY

Moscow PRAVDA in Russian 12 Apr 81 p 2

/Article by Academician Roal'd Zinnurovich Sagdeyev, director, Institute of Space Research, USSR Academy of Sciences: "The Horizons of Knowledge"/

/Text/ In the 20 years that have passed since the triumphant flight of Yu. A. Gagarin, a number of scientific research establishments have been created in our country for the purpose of studying space in the interests of science and the national economy. In the field of the study of space and the Solar System's planets, the leading organization of the USSR Academy of Sciences and the "Interkosmos" council is the USSR Academy of Sciences' Institute of Space Research. In this article, its director writes about some achievements of space science in past years and the prospects for its further development.

The significance of man's venturing into space can be compared to such landmarks in the development of human culture as the discovery of fire, the creation of the wheel, Columbus's voyage and Magellan's circumnavigation of the globe. It has had a great effect on the further expansion of the horizons of knowledge and practical affairs.

As a result of the voyages into space, many scientific disciplines were offered the possibility of expanding the area of their research considerably and their practical utility was determined. Man's breakout into space gave new life to geophysics, radiophysics and mechanics. Space biology and medicine were born, along with satellite oceanography.

In evaluating what has been done, it is possible to say that space research has produced new data on the Earth and its atmosphere, the Sun and the planets of the Solar System, remote areas of the Universe and the interplanetary medium that are frequently not obtainable by other means.

In order to make clearer just what wealth of scientific information space methods are placing at the disposal of specialists, I will present a simple example. Measurements of the parameters of satellite orbits yields some information not only for ballistics experts, but also for studying the physics of the atmosphere, for geodesy, and for the study of the Earth's gravitational field. This is the most accurate method for determining the shape of our planet. It is also useful for

studying other heavenly bodies. It was through the use of the space method that we discovered huge concentrations of masses (mascons) on the visible side of the Moon.

Even the first satellites enabled us to make an important discovery: radiation belts were discovered around our planet. There then followed the discovery of the Earth's plasma shell in the geomagnetic field and flows of solar plasma in interplanetary space.

The study of the processes in the magnetosphere that determine its dynamics and energetics has taken on great importance. In connection with this, we are ever more clearly seeing a transition from separate measurements to a directed, systematic study of phenomena in the magnetosphere using instruments installed in several simultaneously operating spacecraft.

Thanks to the use of space methods, new data have also been obtained about Earth's heavenly neighbors. Among them Venus is attracting special attention, since it is very similar to Earth in a number of parameters. In this example it is interesting to observe similar features in the evolution of the planets that must be known in order to understand the evolution of the "cradle of mankind." Venus is essentially a magnificent experiment of nature, the formulation of which under laboratory conditions is impossible.

The study of comets is also of great interest for planetary cosmology. There are hypotheses that their nuclei are the original material from which the planets formed. Thus, we may be able to find the key to understanding special features of the Solar System's early period of development.

As is well known, one of the brightest and most interesting comets -- Halley's Comet -- approaches the Sun once every 76 years. This event will take place for the first time in the era of space research in 1986, when Halley's Comet can be investigated directly from on board a spacecraft.

Scientific instruments lifted above the limits of the Earth's atmosphere, which absorbs short-wave electromagnetic radiation, made possible a significant enlargement of the "window" through which man perceives the Universe. There appeared a new scientific field: extra-atmospheric astronomy.

It should be mentioned here that the successes achieved in astrophysics are the result of the joint efforts of terrestrial telescopic astronomy, radio astronomy and [illegible] astrophysics, as well as the extensive use of computers for theoretical and [illegible] calculations. Solitary relativistic objects with a mass several times that of the Sun and a diameter of less than 30 kilometers (neutron stars and black holes), as well as binary systems including a normal star (a blue giant, more often than not), the complex phenomena of the overflow of matter from the giant to the relativistic star -- this is only part of the picture drawn by the most recent observations and theoretical calculations.

All-wave astronomy will develop even further, on the basis of a complex of space [illegible] and ground observations. If we talk about the prospects for space astronomy, they are primarily related to the delivery of large telescopes into near-Earth orbit. In principle, right now there are no longer any unsolved

technical problems standing in the way of delivering a telescope with a mirror diameter of several meters beyond the limits of the atmosphere, for the purpose of making observations in the optical, ultraviolet and infrared bands. They will make it possible to investigate objects in the optical band that are 100 times dimmer than those now observable by the largest telescopes in the world. Objects, the existence of which we can only guess at, will be accessible for study.

Finally, farther in the future we can talk about a gigantic orbital observatory with a complex of telescopes.

In recent years much attention has been given to remote sensing of the Earth from space. Right now there is an almost continual flow of data on the Earth's natural resources and environment from satellite-carried multispectral scanners and photographic cameras. For instance, using the multizonal MKF-6M photographic system, cosmonauts on board the "Salyut-6" took a total of more than 50,000 pictures, prints of which are now at the disposal of more than 400 interested organizations in this country.

The "Fragment" multizonal, opticomechanical, scanning television system is functioning successfully on a "Meteor" satellite launched in June 1980. In this system the video information is transmitted to Earth by radio almost as soon as it is gathered. On Earth it undergoes mathematical processing in specialized computers, which makes it possible to find objective criteria for interpreting the video images. The "Fragment" measuring complex is the prototype of instruments of that class, which will be used to investigate natural resources and monitor the environment.

The progress in cosmonautics is also giving birth to new technical fields that, in time, promise to become entire branches of space production. Just about now, among their other experiments in orbit, cosmonauts Vladimir Kovalenok and Viktor Savinykh are continuing the research (begun by other crews) on obtaining new materials and carrying out a number of production processes that cannot be performed on Earth because of the force of gravity and the lack of a high vacuum. The search is on for possibilities for using the special features of space as a specific engineering environment.

The 26th CPSU Congress defined new goals for Soviet science and technology in the 11th Five-Year Plan. In its decisions, the congress states that among the most important problems in the field of natural and technical sciences is the further study and conquest of space in the interests of science, technology and the national economy. For Soviet space investigators this direction for the search will become definitive in the near future.

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CSO: [illegible]

ACADEMICIAN G.I. PETROV INTERVIEWED ON ACHIEVEMENTS AND PROSPECTS OF COSMONAUTICS

Moscow POLITICHESKOYE SAMOOBRAZOVANIYE in Russian No 4, Apr 81 pp 92-98

[Interview with academician G.I. Petrov by special correspondent Yuriy Zaytsev on the occasion of the 20th anniversary of the orbital flight of Yuriy Gagarin; date and place not specified]

[Text] The day of the launch of the "Vostok" ship, April 12th, 1961, has gone down in the calendar as a day of celebration for science and engineering and a day of victory for human genius. The legendary flight of Yuriy Gagarin became an epochal event in history of civilization. Our special correspondent Yuriy Zaytsev met with one of the most famous Soviet specialists in the field of space research Hero of Socialist Labor and winner of the State Prize, academician G.I. Petrov, and asked him to answer a number of questions concerning the development of cosmonautics over the 20 years which have passed since the flight of Gagarin, as well as achievements of Soviet science and engineering in the field of space research and the prospects for their future development.

[Question] Georgiy Ivanovich, the following questions come up with increasing frequency in the press of many nations of the world and, to be sure, even more often in conversations between people: "Why are we storming into space? Are the efforts of the best scientists and engineers of the planet and the expenditures of material resources justified? What will mankind get in return?" What is your opinion in this regard?

[Answer] The mastery of space is for mankind just as natural and logical as going out into the wide spaces of the ocean and taming the air.

The inherent needs of modern science serve as one of the direct and immediate reasons for going into space. They can no longer be satisfied by information which we obtain under ground conditions. The science of the present day is in need of a continuous expansion of that area from which it extracts knowledge. With the appearance of space technology, enormous possibilities have been opened up for the direct penetration of measurement instruments into the previously inaccessible spheres of near-earth and interplanetary space as well as other heavenly bodies. In space, we can observe and study previously unkown processes and phenomena and then utilize the knowledge obtained to solve problems on the ground.

Thus, geologists and geophysicists are no longer limited to the traditional object of study, our native planet. Comparative planetology has become an important integral part of earth science. Using the example of other heavenly bodies, problems are being solved which come up in the study of the structure and evolution of the "cradle of mankind." Specialists in atmospheric physics can now observe the winds and weather on Venus, Mars and Jupiter, and compare them with similar phenomena on earth. Biologists, for whom only one form of life has been known up to now, speculate what life may be like under other conditions, how to seek its attributes, and research is already underway in this direction on the other planets of the solar system. And finally, spacecraft are of direct benefit to people, assisting in the performance of numerous important national economic tasks.

Successes in the mastery of space have promoted a sharp rise in the level of science and engineering in such urgent and advanced fields, shall we say, as the aerodynamics of high speed aircraft and gas powered vehicle engineering, radio and television engineering, automatic control and remote control systems engineering, as well as miniaturization of various technical designs. The penetration of man into space was a powerful stimulus for biology and medicine. Satellites stimulated searches for new energy sources. For example, we are obligated to them for the appearance of semiconductor solar batteries and fuel cells.

Space, with its unprecedented high requirements for product quality, the purity of materials and the reliability of all systems and assemblies forces industry to move up to a level which was not accessible to it even yesterday, to utilize the very latest achievements of science as well as to improve and modernize all production links.

The resolution of such a large complex of scientific and engineering problems became possible only on the basis of theoretical, experimental and prototype design work on the widest scale, which necessitated the participation of representatives from various fields of science and engineering: radio electronics, automation, machine building, metallurgy, medicine, etc. The necessity of providing for their operational interaction, timely execution of the intermediate stages in the design and creation of rocket and space complexes brought to life new, more sophisticated methods of production control. These methods have also found applications in other sectors of engineering.

The demands of cosmonautics have facilitated the resolution of numerous questions in the field of automation, the refinement of remote control theory and hardware, operational monitoring systems for complicated technological processes as well as methods of data processing and transmission. The necessity of setting up observations of spacecraft has led to the design of large automated complexes, the individual links of which are located over large territories. This has had an impact on the development of many global information control systems.

The technology, instrumentation and equipment designed for satellites, automatic interplanetary stations and spacecraft are being effectively utilized at enterprises which produce conventional "ground" products.

For example, one of the very major problems which confronted industry at the outset of the construction of rockets was the development of new materials capable of sustaining the ultralow and ultrahigh temperatures, and were stable under variably

loads, vibrations and sharp changes in stresses. Such materials were created and are now widely used in fields more or less related to plasma processes.

Many metallurgical processes (for example, combining stainless steel with aluminum alloys and welding aluminum alloys), developed for rocket and space technology, are finding broad applications in other sectors of industry. And the production process equipment and tooling developed for stamping the large parts of rocket hulls are being used in shipbuilding.

The application of developmental work performed in the interests of space biology and medicine is also of considerable practical importance in applications to ground practice. Pharmacological preparations for motion sickness are being used in various fields right now, as well as preparations to improve the resistance of the organism to oxygen deficiency and others. The refinement of remote monitoring of the status of the organisms of the cosmonauts during a mission led to the development of remote diagnosis of illnesses.

[Question] All of these examples characterize, so to speak, the indirect impact of cosmonautics on the solution of ground problems. And what can be said about the direct utilization of its achievements?

[Answer] Weather forecasts based on data obtained from space today make it possible to save material resources annually worth 500 to 700 million rubles. Space data not only are of direct value in warning about the commencement of hurricanes, cyclones and their movements, but also aid in the refinement of weather forecasting techniques and the calculation of long term climatic changes.

The launches of the "Raduga" communications satellites, and thereafter the "Ekran" and "Gorizont" into a geostationary orbit started five years ago in the Soviet Union. Along with the usual "Molniya-1", "Molniya-2" and "Molniya-3" communications satellites, more than 40 of them were launched over these years. Communications and repeater satellites have replaced expensive ground installations: in many remote regions of the USSR, they provide for reliable reception of color television transmissions using simple receiving antennas. The state of the art in the development of space engineering will make it possible in the foreseeable future to set up a global communications systems with subscribers at any time and at any point on the globe.

In 1978, the jubilee thousandth satellite in the "Kosmos" series was launched in our nation. It is a space navigation beacon, from which seagoing vessels can determine their position at any point in the world ocean with high accuracy regardless of weather conditions. The "Kosmos-1000" was incorporated in a satellite navigation system consisting of several similar units. The value of such a system is obvious. The data received from the navigational satellites make it possible to substantially reduce the duration of transoceanic trips. This will bring an annual savings amounting to many hundreds of millions of rubles. The further development of the system will make many of the present-day difficulties of maritime navigation ancient history.

In certain sectors of science and engineering, for example, related to the study and efficient utilization of the natural environment, the application of

space technology promises truly revolutionary transformations. The view from space has revealed fundamentally new geological formations, about which nothing was known previously.

[Question] The era of manned spaceflights started 20 years ago. What has been done over the past years in our country in the field of manned flights? Please discuss the achievements which, in your view, are the most remarkable.

[Answer] Missions in space have their own logic and their own development. The first spacecreaft pursued a clear-cut, but relatively narrow goal: to provide for the possibility of manned missions in space in a satellite orbiting the earth and determine how the human organism stands up under flight conditions. The possibility of man's vigorous activity in space was ascertained in missions of various lengths; spacecraft control operations were executed and the capability of the cosmonauts of performing scientific research was studied.

A transition was gradually made to missions of a different quality: multiple crew spacecraft came to replace the single-place ships. Increasing the number of crew members signified an expansion of the circle of tasks which could be performed. The flight of the three-man "Voskhod" ship can be considered as the prototype of the future space expeditions with scientists of different specialties on-board. The launch of the "Voskhod-2" spacecraft also became a qualitatively new step. In this mission, cosmonaut Aleksey Leonov exited the ship into open space for the first time.

The quantity and diversity of the tasks confronting space engineering with the development of science and the national economy have grown unabatedly every year. Life has required the design of multipurpose manned ships, which operate for a long time and are capable of solving a broad group of various kinds of problems. The "Soyuz" craft became such a ship. It was designed for docking as well as for independent orbital missions. At the same time, the "Soyuz" was a prototype of the transport spacecraft which will make regular trips between an orbital station and earth to change crews and deliver cargo.

No one any longer has any doubts that the actual mastery of near-earth space is possible only where long term orbital stations are available. The first such station was launched into a near-earth orbit on April 19th, 1971. The successful flight of the sixth station in the "Salyut" series is continuing today. When designing the "Salyut-6", it was planned that the station would operate for a year and a half. This timeframe has been exceeded by more than two times at the present day. Over this time, 28 cosmonauts have performed research on board the station. The length of the work of the main crews has increased constantly: 96, 140, 175 and 185 days. More than 30 docking operations have been carried out at the space docks in [illegible].

All of this became possible because of the long term concepts embodied in the design of the station. Two docking assemblies provide for the possibility of receiving cargo transport ships, even when one of the docks is occupied by a "Soyuz" delivering a crew into orbit. The "Progresses" carry fuel, foodstuffs, water, oxygen, equipment for repair and everything that is needed for the successful

continuation of the scientific program. In all, more than 20 tons of various cargos have been delivered to orbit by the "Progresses". Instruments and installations have appeared on board, many of which were only in drawings or the thoughts of scientists and designers when the station was launched. For example, such was the situation with the KRT-10 spaceborne radiotelescope.

The mission of the "Salyut-6" is a brilliant illustration of the fact that space has become to us an environemnt for serious thoughtful work. The direction of the domestic space program in the service of the national economy is also clearly seen in it. Judge for yourself. The first expedition in the "Salyut-4" with the crew of Aleksey Gubarev and Georgiy Grechko carried out work related to the resolution of national economic problems in the interests of 40 organizations and departments in our nation. Now though, the number of organizations utilizing information from orbiting stations has increased by a factor of more than 10 times.

The effectiveness of the utilization of orbital stations can also be judged from the following example: the cosmonauts on board the "Salyut-6", by using the multiband MKF-6M photographic system, developed by specialists from the USSR and the GDR, obtain just as much information from a particular region in five minutes as aerial photography of the same region for two years yields.

[Question] Georgiy Ivanovich, as is well known, the first international cosmonaut crews have carried out missions in space on board the "Salyut-6". What do you see as the significance of international cooperation in space?

[Answer] Space research experience quite convincingly demonstrates that international cooperation in space is a command of the times and an objective trend in modern science and engineering. The Soviet Union proceeds from the fact that successes in cosmonautics are the common property of mankind and a contribution to the strengthening of peace in the name of progress, happiness and welfare of people on the earth. It is specifically for this reason that our country is moving ahead with the expansion of international cooperation in the study and mastery of space.

As once formerly in the study of Antarctica, today also the stage of thorough research has begun in the mastery of space, in which the coordination of the efforts of specialists of various countries as well as closer international cooperation in carrying out complex programs take on especially great significance. In essence, any of the great problems of space research in the immediate future: manned flights to the planets of the solar system, the sending of an automatic probe to the nucleus of any comet, the refinement of techniques and hardware for global radio and television communications, as well as the transition to a directed change in climatic conditions, all require the generalization of experience and the scientific and engineering achievements of various nations.

The "Salyut-6" mission made it possible to open the doors for international cooperation in space research even more widely. Emissaries from Czechoslovakia, Poland, the GDR, Bulgaria, Hungary, Viet Nam, Cuba and the Mongolian Peoples Republic have worked fruitfully in space together with Soviet cosmonauts. A series of medical, biological and production process studies have been performed which were prepared by foreign specialists. The results of each mission became the property of all [illegible] participants.

I would like to emphasize the continuity, the unique passing of the baton in the research performed in orbit. Thus, experiments prepared by Czechoslovakian scientists were successfully continued by the Soviet and Polish crew. The Vietnamese and Cuban cosmonauts worked with equipment designed by Bulgarian scientists.

Each international expedition has added its own instruments and installations to that scientific equipment which was already on board the station. The range of scientific research has been considerably expanded in this way.

[Question] It has been repeatedly underscored that the crews of orbital stations not only perform numerous scientific and technical experiments, but themselves become the object of constant observation and detailed study by physicians. What is the importance of these studies?

[Answer] Information is being rapidly acquired today on how successfully man can live and work in space. For this reason, the medical and biological research on board orbital stations is a question of great scientific and practical significance. The major goal of such research is to understand the possible negative consequences of being in weightlessness and to work out antidotes. In our view, the foundation is being laid for future cosmonautics and the living and working conditions which assure that people can stay in space for a long time are being checked. This task is an exceptionally important one for the further mastery of outer space. While there was a question prior to the flight of Yuriy Gagarin as to whether man could exist in weightlessness, it is now formulated differently: how long can one live and work there without damaging one's health?

The long term missions of the cosmonauts on the Soviet "Salyut" orbital stations are helping to obtain the information needed to answer this question. If the days spent on the "Salyut-6" by the four main expeditions are added together, more than a year and a half of continuous work is obtained. Some 362 days in space are counted in the record of Valeriy Ryumin: a record which will hardly be surpassed very soon. World cosmonautics has still not seen anything like it and we rightly speak of unique experience. Today, it can be said with confidence that the major difficulties in supporting long term stays by man in space have been overcome. It is of course still early to talk of complete victory over weightlessness, but real successes in the medical support for space missions have been achieved.

[Question] What do you think: in the future, will manned flights be carried out just as intensively or will man trust the bulk of the work in space to automatic devices? In this regard, how do you conceive of the further organization of work in space?

[Answer] The development of space technology is taking two main paths. One of them is related to the utilization of manned vehicles and orbital stations, while the other is related to the expansion of the applications area of unmanned automated vehicles. Both of these means have their own undisputed advantages. The task consists in providing for a clear-cut interaction of both approaches, and utilizing their advantages to maximum effect.

Manned mission technology will develop along the lines of the successive design of increasingly complex orbital vehicles, outfitted for the performance of various kinds of scientific and engineering research and experiments. Crews of dozens of persons

will be able to work on board such stations, while the stations themselves will operate in orbit for many years. Still, however paradoxical this is, in the development of orbital laboratories it is necessary to take an orientation towards maximum automation of the processes on board the stations.

Operational experience with the "Salyut-6" has shown that one of the major functions of the crew should become that of increasing the station's reliability, as well as increasing its operational service life. The crew is also needed to perform the most delicate and fine operations, and obtain fundamentally new information for which it is impossible to preprogram an automaton. This applies primarily to complex orbital stations, designed for the execution of a broad class of assignments in the fields of astrophysics, environmental sensing, biology and medicine, as well as technology - here the participation of man is essential.

If the path of designing specialized spacecraft is taken though, then such kinds of research can be carried out in an automated mode. Moreover, the presence of man on board the spacecraft will at times simply interfere with the performance of the research. Thus, telescopes today already observe such remote objects that the time for just one exposure is sometimes measured in hours. The axis of the telescope must be guided to a specified point on the celestial sphere and maintained in this position throughout the entire observation time with a precision within hundredths of a second of arc. If a man is on board the spacecraft, then even the beating of his pulse will have an impact on the operational precision of the stabilization and guidance system.

In the opinion of numerous Soviet specialists, the gradual automation of the most frequently repeated operations and control processes for the station, its equipment and scientific instruments is the most reliable approach to improving the efficiency of orbital laboratories. In areas where machines are capable of removing some of the concerns from the crew, one should turn to automation.

[Question] Won't this lead in the final analysis to the fact that with the course of time, there will simply be nothing for man to do in space?

[Answer] I don't think so. The mastery of outer space is unthinkable without man's participation. However, in my opinion, the future of manned space flights is linked primarily to industrial activity in space. One can contemplate the design of production enterprises there for the fabrication of various unique materials, which are difficult or simply impossible to obtain on the earth. Of course, all of this as yet falls within the realm of speculation. But experiments have already been performed, in particular, which show that the quality of semiconductor crystals obtained in weightlessness is substantially improved. The results are promising, but considerable work is still required in this field.

There is another direction for man's work in orbit. Scientists today are thinking, and seriously, about the problems of designing orbital solar electric power stations, which would be able to make a substantial contribution to the earth's power generation. The problems are complex, but they fall within the bounds of possibility for contemporary science and engineering, and as early as the 1980's, work may be started on their realization.

[Question] How do you view the future of automatic space reconnaissance vehicles?

[Answer] It should be said first of all that automation was and remains one of the most reliable tools for getting to know space. Automata are as yet practically the only tool for the direct investigation of the remote regions of the solar system and the planets. The flights of space vehicles, both Soviet and American, have demonstrated that automata have enormous, truly unlimited possibilities. They are capable of carrying out a large complex of scientific investigations: from the derivation of the very first "probe" information to the systematic study of heavenly bodies and physical processes in space. The direct study of the solar system by means of automatic interplanetary stations will obviously make it possible in the coming decade to solve the problem of the origin of the sun and the planets surrounding it.

It is understandable that spacecraft of various types will be needed to solve diverse problems of planetary research. Let us take Venus for example. Balloons are irreplaceable for the study of the dynamics of its atmosphere. They can also be extremely useful for the study of the physical and chemical characteristics of the cloud layer. Special vehicles (probes) are necessary for further study in the field of chemistry of small components and the thermal balance, where these probes make measurements starting from the instant the parachute opens until the vehicle lands, etc.

The most promising trend in the design of automatic planetary stations is the realization of the plans of automatic vehicles which have a high degree of autonomy in traveling on the surface, the capability of perceiving the environment, analyzing it and making decisions on further actions depending on the situation. The design of such automatic units entails the resolution of problems subsumed under the concepts of "artificial intelligence" and "integral robots".

Problems of the delivery of large payload masses to the planets as well as the use of propulsion plants based on new physical principles are additionally to be solved. In the study of remote regions of the solar system, such principles of motion as the solar sail, for example, can prove to be fruitful. The developmental work on nuclear, ion and plasma engines will also go forward, which are substantially more economical in the consumption of the operating fuel.

[Question] Georgiy Ivanovich, what are the main directions proposed for the development of space research in the immediate future

[Answer] I think that the bulk of scientific research will, as before, be carried out in those same near-earth orbits in which the first satellites also flew. And the main links here will remain the study of the upper atmosphere of the earth, the magnetosphere and solar--earth links.

The significance of the work to study near-earth space consists primarily in the fact that this space comprises a portion of man's environment, it interacts directly with the upper layers of the earth's atmosphere and determines many of its parameters: temperature, composition, circulation, etc., as well as the processes in the ionosphere which influence radio communications, especially in the polar regions. Moreover, the earth's ionosphere and magnetosphere are the closest natural plasma system to a researcher, the results of studying which are extremely important for the correct choice of the overall direction for studies of the other planets of the solar system and astrophysical objects.

The possibility of performing experiments with plasma using the near-earth space as a gigantic natural laboratory makes it possible for us to identify many of the processes which occur in the depths of the universe. In this case, besides the passive, purely measurement methods, "active" experiments will play an increasingly greater role every year, i.e., the intrusion into the processes occurring in outer space by means of plasma sources and electron and ion beams. Active experiments will not only assist in better understanding the fundamental processes in space and their causative and consequential links, but also in formulating the question of having a controllable effect on these processes.

It is also planned that solar research outside the atmosphere will be further developed. The main task here is to penetrate more deeply into the essence of the physical phenomena which condition the flare activity and to study the unstable processes on the sun and the processes of the emission of the solar plasma into the interplanetary medium. It is quite important to establish, as applied to urgent ground concerns, in particular the relationship between the changes in the radiation balance of the sun and the earth's climate.

[Question] Will the study of the planets of the solar system using the tools of space technology be continued?

[Answer] There is not any basis for assuming that such research may be terminated for any reason. In my opinion, it should go forward in a broad program, including studies of the physics of planetary bodies and the physics of planetary atmospheres and near-planetary space, as well as space chemistry and cosmogony.

As is well known, the study of Venus occupies one of the important places in the program of Soviet planetary studies. Many of the enigmas of this planet have been deciphered and many of the problems resolved. But new ones have come to replace them, in general, even more difficult ones. We shall enumerate only a few of them.

We do not know, for example, the true reason for the elevated content of inert relict gases on Venus. The reasons for the extraordinarily low water content in the atmosphere of Venus are altogether unclear. Was this planet formed without water, is the water concealed in the crust or was it lost in the process of evolution? It is necessary to establish the chemical composition of the particles of the cloud layer. The mechanism which drives the atmosphere of the planet in motion at velocities of 40 to 70 km [a four day rotation] is unknown. What is the present activity of the interior of the planet: volcanic activity, seismicity? Finally, it is unknown - and it is rather important to know this - when the contemporary thermal mode of the atmosphere and the surface was established: has it existed since the moment the planet was formed or has the climate become more moderate in the course of a rather long initial epoch? No fewer questions can also be posed relative to plasma and magnetic phenomena observed close to Venus and which have not as yet found explanations.

It must be underscored that studies of Venus are a path to a better understanding of the evolution of our own planet.

The [illegible] planets will be the objects of studies in the solar system with the tools of space technology. Comets are also of enormous interest for planetary cosmogony.

For example, one can make an attempt to "match up" with any comet, and by photographing it at close range, catch sight of its nucleus. There are speculations that in the nuclei of comets is that original material from which the planets were formed. For this reason, in studying comets, the key may be found to understanding the specific features of the early period of solar system development.

In particular, there are reasons to think that the famous Tunguska meteorite is the remainder of a comet. Such bodies fall to earth rather frequently. Consequently their role in accretion, in increasing the mass of planets, is obvious, and this circumstance has been inadequately taken into account up until recently. Moreover, calculations show that the density of the Tunguska meteorite was quite low (less than 0.01 g/cm^3) and that it consisted of materials which sublimate easily, even at low temperatures. It is quite important to establish how such enormous clusters are formed, where they are gathered from and what their lifetime is. This is also not without interest for technology, since matter of such a low density has not been successfully created on earth. And, finally, it is important to analyze complex organic compounds of the materials of planets as possible protobiological systems.

I think that it is also essential to devote special attention to the study of the solid matter scattered in interplanetary space. In particular, it would be quite important to obtain undamaged primary material from meteorites. This is apparently possible by means of the long term gathering of extremely small particles by softly slowing them down in a body of very low density, on the order of 0.01 g/cm^3. One can imagine the overall complexity of the problem of deploying in space panels of such material in which some quantity of unburned and unvaporized small dust particles could be collected over a period of several months.

Of course, it would be of undoubted scientific interest to study samples of matter delivered to earth from the surface of asteroids, something which is in principle also possible.

We do not as yet know whether there exists a central symmetry for the sun, for example, in regard to the solar wind and whether its magnetic field is constant or not. Up until now, all space vehicles have been launched in the plane of the ecliptic, and we have seen the sun only from one side. It is important to make a flight around the sun over its poles and by photographing them in the X-ray band, make studies of the solar wind at a distance of no more than 20 million kilometers from the polar regions of the star.

It is likewise very interesting to study the shock wave which is formed as a result of the interaction of the solar wind fluxes with the interstellar medium. By studying the nature of it, the distance from the sun and knowing the parameters of the solar wind, we would be able to judge the density of the interstellar gas, i.e. solve one of the fundamental problems of cosmology.

Finally, I would like to note that the further refinement of space equipment opens up new possibilities for the study of not just our solar system, but the entire universe. It stands to reason that the issue is not the sending of space vehicles to other galaxies. The information contained in electromagnetic radiation propagates more rapidly than any space vehicle can fly. Observations with telescopes

inserted into near-earth orbits will yield much new information on the most remote corners and the most enigmatic objects of the universe, as well as about those gigantic cataclysms which occur in its depths.

Of course, new space telescopes will be needed for this: extremely complex installations, which will be installed on board specialized vehicles. It is necessary to know how large astronomical instruments "behave" in space in order to design them; in particular, it is necessary to ascertain the specific features of their thermal mode, etc. Operational experience with space telescopes on board Soviet orbital stations is undoubtedly an important step on the path to the long term orbital observatories of the future. Work will continue in this direction. There are many problems here, but there are no insoluble ones among them which would not permit placing a telescope with a mirror of several meters diameter in a near-earth orbit in the immediate future.

In a word, there are many enticing ideas, since cosmonautics opens up new perspectives for the development of all sectors of science and engineering which were not seen prior to the start of the space era.

[Question] Taking into account the achievements of cosmonautics over the 20 years which have elapsed since the flight of Yuriy Gagarin, can it be thought that the next 20 years will be sufficient for the realization of all of the projects about which you have been speaking?

[Answer] It seems to me that not just two decades, but rather a considerably greater amount of time is needed for this. But just in our century, in my opinion, the realization of many of the projects is possible in principle. But this is not the only issue.

Man possesses a beautiful ability to dream. And not just to dream, but to continually strive to realize his dreams. Many thousands of scientific collectives participate in substantiating a dream and evaluating its reality. The result of this work is either the death of the dream or its implementation in a project plan, or the birth of a new idea. Cosmonautics is one of the fields in which, it would seem, the impossible dream of traveling to the planets played no small part in the development of a very complex technology which is being refined at an unprecedentedly rapid pace. And it must be thought that much of what we are talking about today as a dream will become a reality tomorrow.

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MILITARY SUPERIORITY ALLEGED AS AIM OF U.S. SHUTTLE

Moscow ZARUBEZHNOYE VOYENNOYE OBOZRENIYE in Russian No 1, Jan 81 pp 55-59

[Article by Engr-Col K. Osmachev: "The 'Shuttle' System"]

[Excerpt] The policy of peace being pursued by the CPSU and the Soviet government is finding widespread support in the hearts of simple people all over the globe. They warmly approve of the initiative of the Soviet Union for the peaceful use of space. However, influential and aggressive circles in Western nations now stand in the way of peace and progress, primarily the U.S., which is striving to exploit various ways of stepping up the arms race, including the militarization of space. The Pentagon views the creation of a powerful accumulation of military equipment in space as an important means of achieving military superiority of the U.S. over the Soviet Union and other socialist countries.

At the present time, judging from communiques in the foreign press, the militaristic circles in the U.S. are investing a special hope in the design and bringing operationally on line of the new Space Shuttle system in the first half of the 1980's. The basis for it will be the manned space vehicle (KK), which is designed for repeated use and the execution of a broad range of missions. Moreover, ground launch complexes, special landing fields, repair shops for preparation of the shuttle spacecraft between missions, as well as a system for communications and data relay through satellites and other facilities and subsystems intended for supporting the reliable operation of the Space Shuttle are all included in it.

The development of this system has been underway since the end of the 1960's and the beginning of the 1970's; financing is being handled primarily via two government agencies in the U.S.: The National Aeronautics and Space Administration (NASA) and the Department of Defense. According to an assessment by foreign specialists, the overall expenditures of these departments for the creation of the Shuttle system will amount to 10 - 12 billion dollars by the beginning of its operational service.

Judging from reports in the foreign press, the development of the Space Shuttle is encountering considerable difficulties, and at the beginning of 1981, is approximately two years behind schedule. In the opinion of American experts, the delay of the first flight of the ship (planned for March of 1979) was due to problems related to the production technology for the main engines and the heat

shielding. Because of this, plans for the operational use of the Shuttle craft were reviewed and there was a considerable overrun of the funds allocated for the development. Thus, for example, 600 million dollars were expended for the fabrication of the orbital stage, something which is almost triple the planned sum. It is also considered that the previously advertised reduction in the cost of boosting payloads into space figured on a per kilogram weight basis will not be fully realized, while bringing the technical characteristics of the craft up to the specified values (such as the cargo capacity, the between launch preparation cycle and others) will require a few more years yet after the craft is turned over for operational service.

Despite the considerable delays and difficulties in implementing the program for the creation of the Shuttle spacecraft, the U.S. Department of Defense continues to consider this program and important component of its space policy. Thus, in all of the models for the use of the Space Shuttle which have been repeatedly reviewed, the fraction of launches set aside officially just for the Department of Defense has not once been reduced below 20 to 25 percent of the total number of launches. This number does not include launches made by NASA and industrial firms, the results of which the Pentagon can use for its own purposes. If the model provides for a reduction in the overall number of launches, the curtailment is made primarily at the expense of civilian programs.

Simultaneously with the construction by NASA of the launch and landing as well as the equipment installation and testing complex for servicing the Shuttle system at Cape Kennedy (in the state of Florida) and the orbital mission control center in Houston (Texas), the United States Air Force which is responsible for the military space program is constructing its own launch and other complexes for similar purposes at the Vandenberg airbase (California) and close to the NORAD command center (Colorado). These complexes are intended exclusively to support launches in the interests of the Defense Department, while the NASA complexes will carry out mission for both departments. Moreover, NASA and the U.S. govertment are creating the most favorable conditions for the Defense Department to utilize the Space Shuttle. For example, the cost of military satellite launches carried out by NASA will run the defense department only two-thirds of the cost to commercial organizations in the U.S. and other nations, as well as the European Space Agency and Canada.

Articles and remarks have repeatedly appeared in American military and special technical publications over the last several years in which the operational service of the Space Shuttle is linked to the testing and expansion of new weapons systems and combat equipment. In particular, the following have been mentioned: placing the warheads of ballistic missiles on board, as well as laser and beam weapons, tools for the recognition and destruction of satellites belonging to other countries, and reconnaisance equipment and other kinds of military hardware. The aggressive militarists of the U.S. tie their hopes regarding an acceleration of the militarization of space and the transfer of military operations there to the utilization of the Space Shuttle system.

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LAUNCH TABLE

LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
28 Apr 81	Cosmos-1268	391 km	217 km	90.3 min	70.4
7 May 81	Cosmos-1269	833 km	797 km	100.9 min	74
15 May 81	Meteor-2	904 km	868 km	102.5 min	81.3
		(Weather satellite with equipment to obtain global images of earth's surface and cloud cover in the visible and IR bands and for study of radiation in near-earth space)			
18 May 81	Cosmos-1270	370 km	180 km	89.7 min	64.9
19 May 81	Cosmos-1271	670 km	628 km	97.5 min	81.2
21 May 81	Cosmos-1272	403 km	217 km	90.4 min	70.4
22 May 81	Cosmos-1273	277 km	221 km	89.2 min	82.3
		(Data obtained will be processed at the State Scientific-Research Center "Priroda")			
3 Jun 81	Cosmos-1274	380 km	183 km	89.3 min	67.2
4 Jun 81	Cosmos-1275	1,026 km	983 km	104.9 min	67.2
9 Jun 81	Molniya-3	40,837 km	471 km	12 hrs 16 min	62.8
		(Communications satellite for long-distance telephone and telegraph communication and TV broadcasts in the "Orbita" network)			
16 Jun 81	Cosmos-1276	265 km	224 km	89.1 min	82.3
		(Data obtained will be processed at the State Scientific-Research Center "Priroda")			
17 Jun 81	Cosmos-1277	393 km	216 km	90.3 min	70.4
19 Jun 81	Cosmos-1278	40,165 km	614 km	12 hrs 06 min	62.8
24 Jun 81	Molniya-1	40,640 km	645 km	12 hrs 16 min	62.8
		(Communications satellite for long-distance telephone and telegraph communication and TV broadcasting in the "Orbita" network)			

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
26 Jun 81	Ekran	35,636 km	--	23 hrs 46 min	0.4
		(TV communications satellite operating in decimeter band; inserted into near-stationary circular orbit; international registration index "Statsionar-T")			
1 Jul 81	Cosmos-1279	385 km	218 km	90.3 min	70.4
2 Jul 81	Cosmos-1280	312 km	222 km	89.5 min	82.3
		(Data obtained will be processed at the State Scientific-Research Center "Priroda")			
7 Jul 81	Cosmos-1281	419 km	208 km	90.4 min	72.8
10 Jul 81	Meteor-Priroda	688 km	611 km	97.6 min	97.9
		(Earth resources satellite carrying TV scanning equipment and an experimental 3-channel microwave radiometer; also carries equipment developed by Bulgarian specialists under "Bulgaria-1300" program: multichannel visible & near IR spectrometer, single-channel microwave radiometer, computer)			
10 Jul 81	Iskra	Small satellite launched together with "Meteor-Priroda" and with similar orbital parameters; created by a student design bureau of Moscow Aviation Institute			
15 Jul 81	Cosmos-1282	357 km	179 km	89.6 min	64.9

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